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COVER PHOTO - Sacramento River at the junction of Steamboat Slough. Sutter Slough can be seen in the upper part of the picture Pear orchards line the river and sloughs Fields of grain, corn, and tomatoes are irrigated through a system of canals and ditches

Department of
Water Resources

Bulletin 168

Sacramento Valley Water Use Survey 1977

October 1978

Huey D. Johnson
Secretary for Resources

The Resources
Agency

Edmund G. Brown Jr.
Governor

State of
California

Ronald B. Robie
Director

Department of
Water Resources

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Valuable cooperation and assistance were provided by water users and by public and private agencies in the field work and preparation of data for this report on Sacramento Valley water use.

The U. S. Department of Interior, Bureau of Reclamation, furnished data on reservoir operation, streamflow, diversions, and Delta salinity.

The U. S. Geological Survey provided streamflow and ground water level data, and the National Weather Service furnished streamflow and precipitation records.

The Pacific Gas and Electric Company and the Sacramento Municipal Utility District made available records of power consumption for diversions computations.

The State Water Resources Control Board, Division of Water Rights, furnished information on water rights and water use on Sacramento Valley streams and participated in land-use surveys and field inspections in the Delta.

Mr. William O. Pruitt, Irrigation Engineer, University of California at Davis, furnished data and information concerning climatic conditions and evapotranspiration factors.

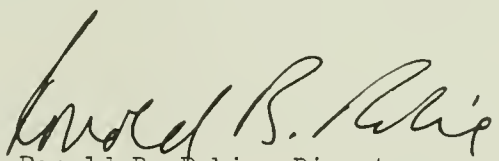
FOREWORD

The combined effect of substantially below-normal precipitation during 1976 and record low precipitation in 1977 imposed an unusual burden on the operation of both the State Water Project and the Central Valley Project in meeting their water delivery objectives.

This is the second report on the Sacramento Valley Water Use Survey that began in 1976 to (1) learn more about dry-year hydrology, and (2) obtain information that would help manage our limited water supplies. This report presents the findings of that survey for 1977.

The report contains data and analyses of precipitation, runoff, streamflow, diversions, accretions, land and water use, water rights, Delta salinity, and other information necessary for determining the effect of the drought on the Sacramento and Feather Rivers and in the Sacramento-San Joaquin Delta. It also shows graphically the changes that occurred in ground water levels within the Sacramento Valley between 1975 and 1977.

Federal and other public agencies, as well as private agencies, have assisted in the survey by providing a portion of the data presented.



Ronald B. Robie, Director
Department of Water Resources
The Resources Agency
State of California

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STATE OF CALIFORNIA
Edmund G. Brown Jr., Governor

THE RESOURCES AGENCY
Huey D. Johnson, Secretary for Resources

DEPARTMENT OF WATER RESOURCES
Ronald B. Robie, Director

Charles R. Shoemaker
Acting Deputy Director

Gerald H. Meral
Deputy Director

Robert W. James
Deputy Director

Jack B. Johnston
Acting Assistant Director

CENTRAL DISTRICT

Wayne MacRostie . . . . . Chief

This report was prepared by:

Lee W. Carter . . . . . Chief, Data and Operations Branch
Arthur L. Winslow, Jr. . . . . Assoc. Engineer, W.R.
James C. Mosley . . . . . Assoc. Engineer, W.R.
Donald H. Taylor . . . . . Asst. Engineer, W.R.

Assisted by:

Edward J. Labrie . . . . . Senior Engineer, W.R., Central District
Thomas Mackey . . . . . Senior Engineer, W.R., Northern District
George K. Sato . . Sr. Land & Water Use Analyst, Central District
John W. Shannon . . . . . Land & Water Use Consultant
Y. John Kono . . Assoc. Land & Water Use Analyst, Central District
Gene H. Novak . . Assoc. Land & Water Use Analyst, Central District
Dale E. Dinger . . . . . Senior Delineator, Central District
Harry Inouye . . . . . Delineator, Central District
Mary Mulligan . . . . . Senior Stenographer, Central District
Cathy Wilson . . . . Word Processing Technician, Central District

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The California Water Commission serves as a policy advisory body to the Director of Water Resources on all California water resources matters. The nine-member citizen Commission provides a water resources forum for the people of the State, acts as liaison between the legislative and executive branches of State Government, and coordinates Federal, State, and local water resources efforts.

Chapter I. INTRODUCTION

Water supplies markedly affect the lives of California citizens and the State's economy. Nonirrigated farmlands, such as pasture and grain, depend on direct rainfall. Irrigated areas depend not only on direct rainfall but also on water stored in surface and ground water reservoirs. Snow, which is "stored" in the higher elevations during winter, is a major source of runoff in the late spring and early summer. Both rainfall and snowmelt runoff are stored in foothill reservoirs and later released for irrigation and many other uses.

During the 1976-77 season, California experienced below-normal precipitation throughout the State. In the Sacramento Valley, precipitation from October 1, 1976, through August 31, 1977, ranged from 30 to 50 percent of normal. A moderate-sized storm occurred in September 1977, but it did not produce significant runoff because most of the precipitation was absorbed by dry watersheds. The snowpack in Northern and Central California was close to the lowest of record. Unimpaired runoff in the Sacramento Valley ranged from about 14 percent of normal in the southern portions to about 43 percent at Red Bluff. The annual unimpaired runoff for the Sacramento and San Joaquin Rivers to the Delta was only 27 percent of normal.

Sacramento Valley Water Use Survey

During the early part of the 1976 irrigation season, water supply inventories showed that reservoirs were being depleted at a greater rate than had been estimated. A substantial part of the increased use was directly related to the below-normal precipitation. Less apparent, however, was the reason for higher-than-estimated losses of water between the upstream reservoirs and the Delta.

The Sacramento Valley Water Use Survey program was developed cooperatively by the Department of Water Resources (Department), the U. S. Bureau of Reclamation (USBR), and the State Water Resources Control Board (SWRCB), to determine why increased releases were necessary to meet water demands and to provide supplemental information that would help managers make decisions to equitably distribute the limited water supplies. The program was oriented primarily toward measurement of water quantities. The only water quality problem considered was salinity in the Delta.

Scope of Survey

The Survey, which began in July 1976 and continued in 1977, covered the area from Shasta Dam on the north (Plate 1) to Vernalis on the south (Plate 2). The survey included the service area of the Sacramento-San Joaquin Delta as shown on Plate 2.

Records of monthly flows at streamflow gaging stations operated by State and Federal agencies along the major streams and tributaries in the Sacramento Valley and around the periphery of the Delta are included in the survey. Also included are estimates and measurements of monthly diversions and return flow along major streams. The location of stream-gaging stations, return flows, and precipitation stations, and of major diversions and places of use are shown on Plate 3.

Records of inflow, storage, and release for Shasta, Folsom, and Oroville Lakes and exports from the Delta were obtained from project operators. The scope of the survey also included compilation of records of salinity in the western Delta derived from continuous electrical conductivity recorders, and data on climatic and runoff conditions.

Scope of Report

This report contains a summary of hydrologic data collected during the 1977 irrigation season. The basic data presented were compiled from information currently being collected under ongoing programs and from additional field work undertaken specifically for this survey.

Some of the basic data presented herein are preliminary and subject to revision. Final data will be included in periodic published reports of the Department and other cooperating agencies.

Dry Year Program of the State Water Resources Control Board (SWRCB)

The SWRCB has responsibilities for administration of programs dealing with water rights and water quality. During the drought, many interests were concerned that water users would inadvertently interfere with water rights of others if not forewarned about the availability of water. To reduce this possibility, the Dry Year Program was established as a function within the Division of Water Rights. This program was designed to protect and enforce priorities of surface water users. Activities conducted under this program were closely allied with the activities conducted under the Sacramento Valley Water Use Survey. Therefore, a free interchange of information was made between the two programs.

The program elements directly related to the Sacramento Valley Water Use Survey program were as follows:

1. Estimates were made of the water available to satisfy water rights. Over 3,800 notices were sent to water users in the central and northern parts of the State requesting them to conserve water and to divert only water to which they were entitled.

2. Additional staff was assigned to respond to an unprecedented increase in water rights complaints.

3. An interagency agreement was entered into between the SWRCB and the Department. Under the agreement, the Department supplied personnel to investigate uses of water under appropriative and assumed riparian rights on the Sacramento River and its main tributaries and appropriative diverters in the Delta. The Department also conducted a crop survey of the Delta lowlands.

Information collected under the Dry Year Program has been considered and information concerning land and water use in the Delta has been incorporated into this report.

Summary

The 1976-77 unimpaired runoff of the Sacramento-San Joaquin Rivers to the Delta was only 27 percent of normal, the lowest since records have been maintained. Reservoir storage on December 1, 1977, was only 30 percent of normal. During 1976 and 1977 irrigation seasons, stored water was depleted at rates in excess of planned project operations.

Although water conservation measures had been initiated in 1976, increased emphasis was given to reductions in water use during 1977. The USBR announced that only 75 percent of the normal contract quantities would be delivered to water users along the Sacramento River. The Department limited deliveries to contractors on the Feather River to only 50 percent of normal entitlements. The SWRCB implemented a Dry Year Program and mailed notices to water right holders announcing the forecast of limited water supplies and requesting their cooperation in diverting only water to

which they were entitled. The SWRCB also made field investigations of water right complaints in an effort to enforce water right entitlements.

Diversions from the main river channels above Sacramento during 1977 were about 75 percent of the diversions during the 1976 irrigation season. Reductions in river diversions were attributed to: (1) water contract restrictions placed on water diverters by the USBR and the Department, (2) compliance with notices sent to water users by the SWRCB, and (3) new wells drilled to supplement surface diversions.

Over 95 percent of the appropriative rights along the main stem of the Sacramento and Feather Rivers were contractually augmented by stored water. Water diverted without proper rights from these channels was estimated to be less than 1 percent of the total water diverted.

Ground water levels declined as much as 18 metres (60 feet) between the spring of 1975 and the spring of 1977 in the southern portion of the Sacramento Valley west of Knights Landing. Data and information were insufficient to estimate the amount of ground water recharge from river channels and the amount of pumping from the ground water basin. However, most of the decline in water levels upstream from Colusa was attributed to lack of water supply for recharge. In the reach downstream from Colusa, drawdown in excess of about 1.5 metres (5 feet) was attributed to increased pumping. The greatest losses in both ground and surface water occurred in the reach from Colusa to Sacramento.

Land use in the Delta during 1977 did not change substantially from 1976. In 1976, the total irrigated area and the double-cropped land was 203 900 hectares (503,800 acres) and 6 176 hectares (15,300 acres) respectively, as compared with 207 500 hectares (512,800 acres) and 3 747 hectares (9,260 acres), respectively, for 1977. Changes in crop patterns did not result in any substantial reduction in water use. The total water use during the 1976 season was computed to be 2 156 cubic hectometres (1,748,000 acre-feet), as compared with 2 125 cubic hectometres (1,722,000 acre-feet) for 1977.

Water was computed to be available until the first part of July to satisfy riparian uses. On a mean monthly flow basis, during 1977, shortages of water to satisfy riparian rights and Delta outflow prevailed during the months of July and August. Assumed riparian use of water within the Sacramento Valley and in the Delta service area exceeded the nonproject runoff by approximately 360 cubic hectometres (290,000 acre-feet) during these months. Estimated project water used by appropriators in the Delta uplands during June, July and August was about 165 cubic hectometres (135,000 acre-feet).

Salinity was allowed to move into the Delta channels in compliance with emergency regulations of the SWRCB. The daily maximum 1 000 mg/l chloride concentration level moved in as far as the vicinity of Rio Vista on the Sacramento River and Jersey Point on the San Joaquin River.

Conclusions

1. The restriction imposed by contracts for water from the Central Valley Project and the State Water Project was the principal reason for reductions in diversions from the Sacramento and Feather Rivers during the 1977 irrigation season.

2. Minimal reductions from the 1976 level in the amount of water used by agricultural crops in the Delta service area were achieved. However, some impairments in water quality occurred, particularly in the western Delta, from the relaxation in water quality criteria.

3. Stored water from the Central Valley Project and the State Water Project was used to provide acceptable quality of water within the Delta. The Delta service area benefited from this use of stored water. Impairments in water quality resulted in minimal reduction in crop yields.

4. Stored water was used to supplement riparian water supplies for assumed riparian land in the Delta service area during July and August, and was used by Delta uplands appropriators during the latter part of June and during July and August.

5. Additional data are needed to quantify ground water and its movement. Ground water data collection should be continued to monitor ground water level trends and to inventory and classify wells to create a data base for future ground water investigations.

Sacramento River at Hood. The major inflow tributary to the Delta.

Chapter II. WATER SUPPLY

During the 1977 irrigation season, very low flows of the Sacramento River were caused by diversions from the river for irrigation, low accretions to the river by ground water seepage, and minimum releases of water from Shasta, Trinity, Oroville, Folsom, and other reservoirs.

Water in the Delta service area is supplied from (1) direct precipitation, (2) tributary inflows, and (3) ground water contributions to the Delta uplands. Water is removed from the Delta by (1) evaporation and transpiration (agriculture, water surfaces, riparian vegetation, etc.), (2) exportation to areas outside of the Delta, (3) urban uses within the Delta, and (4) outflows into Suisun Bay.

Precipitation

In the Sacramento Valley, direct precipitation is generally a source of water for growing crops during early spring. In normal years, rainstorms during March and April substantially reduce the demand for irrigation diversions during those months and affect the demand in the same month from year to year. During 1977, rainfall in the Valley was well below normal for January through April, and temperatures during March and April were warmer than normal, resulting in increased diversions as compared with a year of normal precipitation and temperature.

Table 1 presents the monthly precipitation for January through October 1977 at stations throughout the Sacramento Valley and Delta areas. The corresponding normal monthly precipitation is also shown. (The precipitation stations are shown on Plates 2 and 3.) At the bottom of Table 1, the average monthly precipitation for the Delta service area is shown. Also, the total monthly acre-feet based on the average precipitation for both the lowlands and uplands areas are shown.

Runoff Comparisons

To compare runoff conditions on a particular stream, the average or normal runoff for that stream over a period of years must be computed. Deviations from the normal are expressed as a percentage for each year considered. Runoff comparisons are based on percentages of average determined for the 50-years October 1920 through September 1970.

Since runoff conditions are affected by man-made impairments, an equitable comparison throughout the water year requires that all runoff quantities be adjusted to unimpaired runoff. Unimpaired runoff is determined from measured (actual) runoff by adjusting for the quantitative effect of storage development, diversions or importations above the point where the flow is measured.

Table 2 compares unimpaired runoff for the major streams tributary to the Sacramento Valley and Delta for 1923-24, 1930-31 and 1933-34 through 1976-77.

Table 3 presents a monthly comparison of runoff for October 1976 through October 1977, for the major streams tributary to the Sacramento Valley and Delta. The water year totals shown at the bottom of the table do not include October 1977.

Reservoir Storage

The dry period from January 1976 to November 1977, resulted in drastically reduced inflow to the storage reservoirs in the Sacramento River drainage basin. This lack of inflow, plus the heavy demands for irrigation water and for Delta salinity control flows, resulted in extremely low reservoir levels in October 1977. On December 1, 1977, the storage was about 30 percent of the normal for that date.

Storms in December 1977 and January 1978, changed the water picture. Based on February 1, 1978, forecasts, the Department and the USBR announced plans to provide full entitlements to water contractors during 1978. Above normal rainfall conditions during February, March and April of 1978 made water available to make up deficiencies sustained by water contractors during 1977 and also to provide surplus water.

Table 4 shows the water in storage for major reservoirs on tributaries to the Sacramento Basin as of December 1, 1977, compared to the same time in the previous 2 years. To summarize this data, water storage in all reservoirs in a given stream system has been combined (as if there were only one reservoir for each stream), and shown on Plate 4.

Reservoir Operations

Most of the winter runoff made available for summer use in the Sacramento Valley basin is regulated by Shasta Lake on the Sacramento River, Folsom Lake on the American River, and Lake Oroville on the Feather River.

Table 5 presents monthly reservoir operations for Shasta Lake, Keswick Reservoir, Oroville-Thermalito Reservoir complex, Folsom Lake, and Lake Natoma for March through October 1977.

Inflow to Keswick Reservoir included releases from Shasta Lake and water imported from the Trinity River Division of the Central Valley Project, which enters Keswick Reservoir via Spring Creek Power Plant.

The computed inflows shown for Lake Oroville in Table 5 do not include amounts pumped back into the reservoir during May and June. The release figures shown are the amounts of water passing through the dam via the Hyatt Power Plant minus the quantities pumped back, to indicate the net amount of inflow into the Thermalito Complex from Lake Oroville. (Flows from Lake Oroville to Palermo Canal are not included in the release figures, since these flows do not enter the Thermalito Complex.) Water also enters the Thermalito Complex below Oroville Dam through the Kelley Ridge Power Plant and is shown in Table 16.

Under the heading, "Thermalito Diversion Dam Release to River", Table 5 gives the amounts released through the diversion dam, over the Fish Barrier Dam, and through the Feather River Fish Hatchery, which are located between the diversion dam and the Thermalito Afterbay release facilities. Quantities shown for Thermalito Afterbay release are the regulated amounts of water released into the Feather River from Thermalito Afterbay. These releases, plus releases from the diversion dam (assuming no accretions or losses en route) make up the total flow in the Feather River below the Thermalito Complex.

Inflows to Lake Natoma shown in Table 5 are equivalent to the releases through Folsom Dam except for some minor accretions or losses. Releases to the American River below Nimbus Dam include releases made for the fish hatchery, but do not include diversions to Folsom South Canal.

The inflows shown in Table 5 for Shasta, Oroville, and Folsom Lakes are "computed inflows" developed from measured data on storage, release, precipitation, and evaporation. The computed inflows are an estimate of the flows that would have passed the site of the respective dams if the dams were nonexistent.

Streamflow

The main streams of the Sacramento Valley are the Sacramento, Feather, Yuba, and American Rivers. Major tributary streams entering the Sacramento River above Red Bluff are Cottonwood, Battle, and Cow Creeks. Below Red

U. S. Geological Survey measuring the flow of the Sacramento River.

Bluff, Mill, Deer, and Big Chico Creeks enter the river from the east and Elder, Thomes, and Stony Creeks enter from the west. Considerable flow is lost by percolation or used by diverters between the foothills (where these creeks are measured) and the river, a distance of 15 to 30 kilometres (10 to 20 miles).

In July 1977, the minor streams were observed from the air. Each creek bed was dry at the point where it entered the river. The contributions from these and other creeks were adjusted to account for water lost below the foothill measurement site in Table 15.

Gaging Stations

Gaging stations record water levels at various points on rivers and drains and through large drainage and canal pumping plants upstream from Sacramento. Flow measurements at each station determine a relationship between gage height and flow. From this relationship and a record of gage heights, daily and monthly flows were computed.

Table 6 shows quantities of water passing the principal gaging stations on the Sacramento, Feather, and American Rivers; on various streams tributary to the Sacramento and Feather Rivers; and on streams tributary to the Delta. Many of the flows presented in Table 6 were measured by the U. S. Geological Survey (USGS).

Table 6 also shows irrigation return flows (insofar as these were obtainable) and exports from the Delta. In many instances, these records of flow were obtained by methods other than those described for regular gaging stations. For example, for pumped drainage, records are obtained by rating the pump.

The locations of the surface water measurement stations are shown on Plate 2 and Plate 3.

Drainage pump in the Delta lowlands.

Accretions to Streamflow

Accretions consist of surface and ground water inflows to the stream from any source and include tributary inflows, surface and subsurface return flow from irrigation, precipitation, and percolation from adjacent ground water. These accretions are of major importance as additional irrigation supplies.

Accretions can be either measured or unmeasured. Measured accretions are surface accretions that can be measured by gaging stations or other means. These are shown in Table 6 as minor tributaries and irrigation return flow stations. Unmeasured accretions are computed quantities and make up the balance between measured inflows and outflows along a particular stream reach. Tables 15 and 16 summarize measured monthly flows and diversions, along with computed monthly accretions (or losses, as shown by a negative figure) occurring along each reach of each stream between gaging stations.

The term "return flow" is used to indicate that portion of diverted water that is not used and that finds its way by surface drainage or by percolation to the original source. It is then available for reuse by other diverters. The computed accretions within a stream reach may include substantial amounts of return flow, as well as accretions from other sources.

Irrigation Return Flow

Irrigation practices in the Sacramento Valley have historically provided considerable return flow to the river. Prior to 1976 and 1977 irrigation seasons, the return flow amounted to approximately 30 percent of the applied irrigation water. Much of the return flow consisted of carriage water - water that is excess to the entitlements but necessary to force adequate water to the last diverter on the conveyance canal. The carriage water was not reused by the diverter, but became available for use by downstream diverters.

Water project operations have, in prior years, benefited by a considerable quantity of return flow to meet the needs of downstream diverters and Delta requirements. During the extremely dry year of 1977, it was estimated that less than 15 percent of the diverted water returned to the river.

Ground Water Conditions and Changes

During this drought, a large number of wells in the Sacramento Valley were put into production and ground water was used in large quantities. This, along with the lack of normal recharge of the ground water basin, resulted in a drop in ground water levels. Many wells have shown the lowest levels of record.

The following sections document the extent of these changes in ground water conditions. Possible effects of these ground water conditions are discussed in Chapter IV under "Interrelationship between Surface and Ground Water". Ground water data used in this survey were collected by the Department's cooperative ground water level measurement program and by the USGS. Between July 1977 and January 1978, the USGS measured wells located within about 3 kilometres (2 miles) of the Sacramento River at major bridge crossings every 2 or 3 weeks.

Ground water level contour maps of the Sacramento Valley between Red Bluff and Sacramento were prepared for springtime water level measurements of 1975 and 1977 (see Plates 5 and 6). A contour map also was drawn showing changes in water level measurements between the above 2 years (see Plate 7). An additional reference point was a map showing water level contours for spring 1968, the last time prior to 1975 that such a map was prepared. With these contour maps as a base, water level profiles transverse to the Sacramento River

were drawn at each gaging station between Red Bluff and Sacramento (see Figures 1 and 2). The USGS, using its recently collected data, also plotted water level profiles transverse to the river at a number of locations, some of which were at river gages, showing ground water levels. This information has been considered in this report.

The amount of ground water depleted from the basin between Sacramento and Red Bluff (within the area covered by contours) from spring 1975 to spring 1977, was estimated to be about 2 100 cubic hectometres (1,700,000 acre-feet). This estimate was derived from area and water levels shown on the contour maps, using an average specific yield factor of 7 percent, and assuming that all water level contours represent zones of free ground water. Actually, many well measurements represent pressure levels in confined zones, which if excluded would result in a change in storage less than 2 100 cubic hectometres (1,700,000 acre-feet).

At the end of the 1977 irrigation season, the ground water levels were measured. No contour map was prepared; however, an estimate was made of the depletion of ground water from the basin during the period from spring 1977 to fall 1977 by taking the average change in ground water level for each quarter of each township (9 square miles) and multiplying that by the specific yield for that area. The estimated total depletion north of Sacramento was approximately 1 200 cubic hectometres (1,000,000 acre-feet). Of this total depletion, about 700 cubic hectometres (600,000 acre-feet) occurred south of Colusa and about 500 cubic hectometres (400,000 acre-feet) occurred north of Colusa.

Areal Summary of Changes

The following paragraphs describe spring 1977 ground water conditions and changes in water levels since spring 1975 in several areas of the Sacramento Valley. Also described are some findings of the USGS well measurement program conducted in July and August 1977. The spring 1968 water levels did not vary greatly from those of spring 1975, which indicates that the major declines began in 1975. Table 7 presents a summary, by county, of the average change per measured well in ground water levels between the spring measurements of 1975 and 1977. Data for Yolo and Sacramento Counties pertain only to wells located in the area north of the latitude of Sacramento (north of township 8 north).

North of Hamilton City. In the area north of Hamilton City, spring 1977 ground water contours, as in the past, showed a general slope of the ground water table toward the Sacramento River and southward down the valley (Plate 6). These contours, when compared with those of spring 1975, showed declines in ground water levels generally from 3 to 6 metres (10 to 20 feet)(see Figure 1 and Plate 7).

Since agricultural development in this area is not extensive, increased pumping for irrigation probably was not the major factor in the decline of ground water levels. Ground water would tend to move southward to lower elevations in the basin and into the river, where hydraulically possible. The lack of normal recharge would result in a net depletion of ground water in storage.

Ground water levels at the Tehama-Los Molinos bridge crossing, the most northerly measurement location, were about 1 to 1.5 metres (3 to 5 feet) higher than the river stage in summer 1977. Ground water, therefore, could flow toward the river at that point. Farther downstream, ground water levels dropped below the river stage, about 1.8 metres (6 feet) at Vina Bridge and 2.5 to 4 metres (8 to 13 feet) at Hamilton City. These differences in head between surface and ground water indicate that water could flow from the river toward the ground water basin.

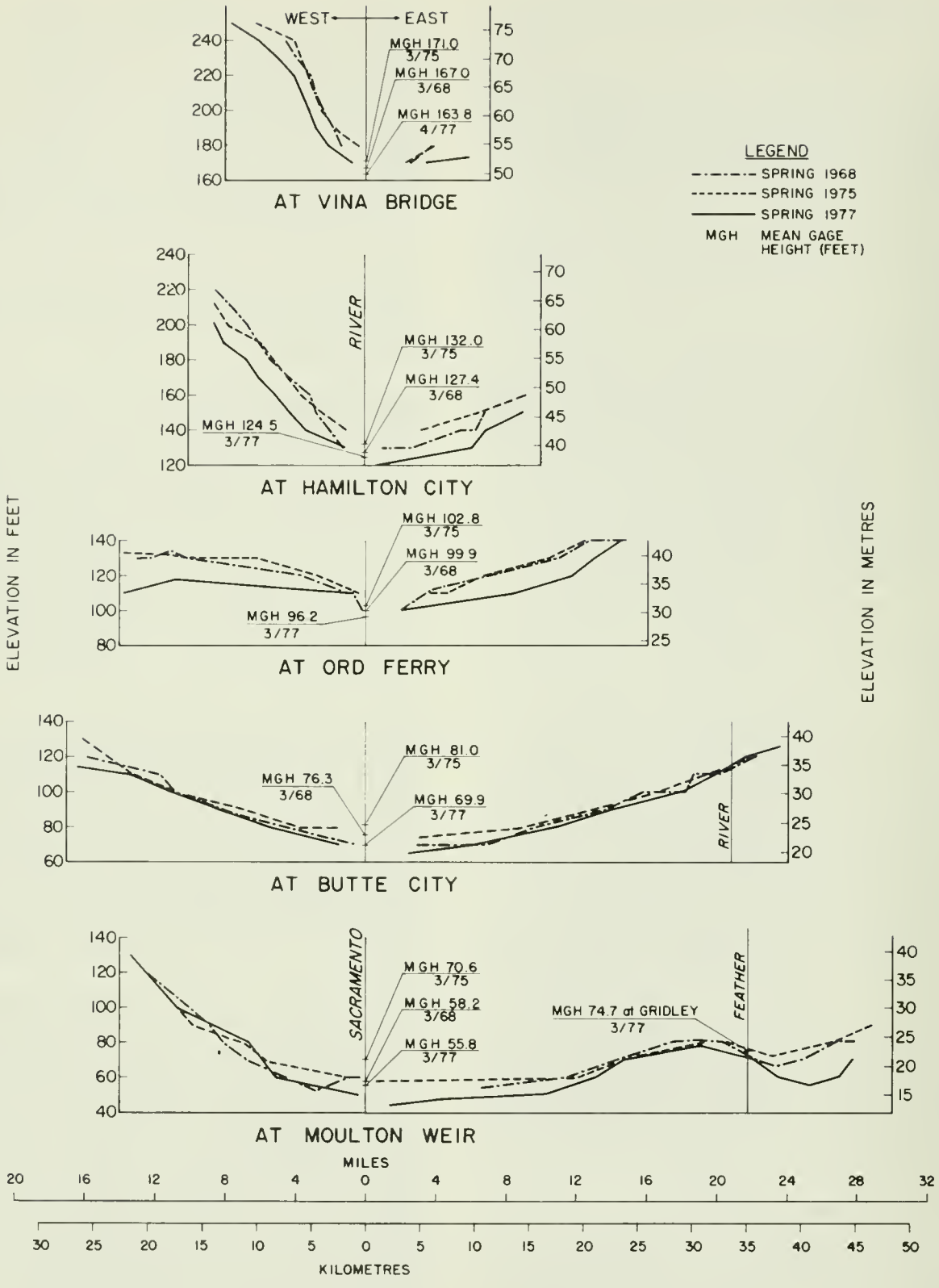


Figure 1. GROUND WATER LEVEL PROFILES UPSTREAM FROM COLUSA

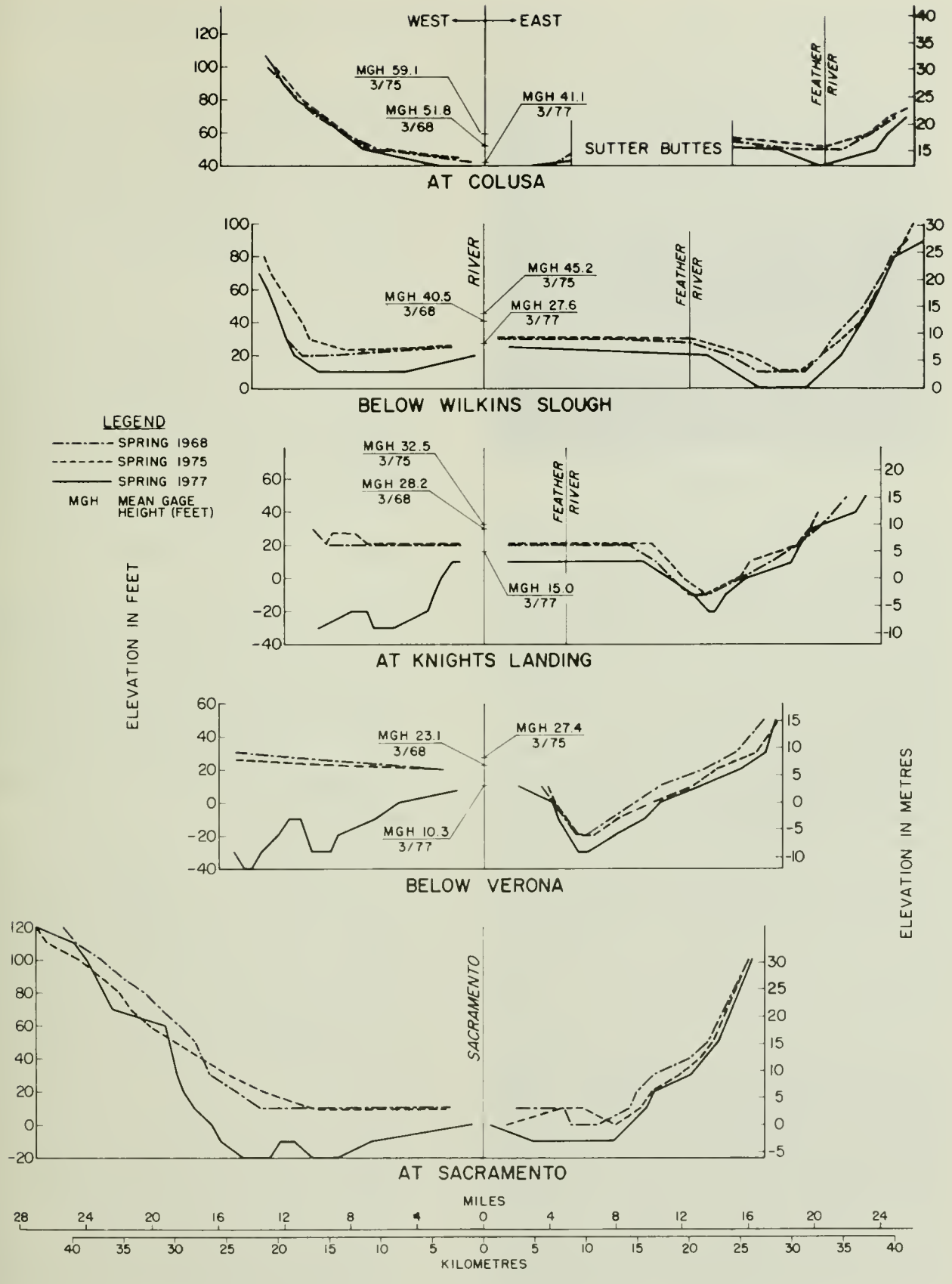


Figure 2. GROUND WATER LEVEL PROFILES DOWNSTREAM FROM COLUSA

Hamilton City to Colusa. From Hamilton City southward to about Butte City, where considerable ground water is used. water levels for the most part declined about 3 to 4.5 metres (10 to 15 feet) on both sides of the river between the spring measurements of 1975 and 1977. From Butte City southward to Colusa, declines were generally in the order of 1 to 2 metres (3 to 6 feet). In general, the water table continued to slope toward the river and down the valley (see Figure 1 and Plates 6 and 7).

USGS profiles showed ground water levels near the river remaining below the river stage, varying up to 4 metres (13 feet) at Colusa. Water in the river, therefore, would tend to seep into the adjacent ground water basin.

South of Colusa. In the Colusa County area south of Colusa, the spring 1977 water levels generally were 3 to 6 metres (10 to 20 feet) below those of spring 1975. The largest drops in the water table occurred in Yolo County, particularly south and west of Knights Landing. Deep pumping depressions have developed in some areas 6 to 20 kilometres (4 to 12 miles) west of the Sacramento River. Depressions in the vicinity of Woodland, for example, were more than 15 metres (50 feet) below the spring 1975 water levels (Plate 7).

In Sutter and Sacramento Counties, water levels for the most part declined less than 2 metres (6 feet). In Placer County, the decline was about 1.5 to 4.5 metres (5 to 15 feet)(see Plates 7 and 8).

In the area south of Knights Landing, the water table in spring 1975 was only slightly below the river stage. In the spring of 1977 the water table generally sloped steeply toward the large pumping depressions about 3 kilometres (2 miles) west of the river. However, USGS profiles show the water level in wells near the river to be only slightly below the river stage, indicating that the water table is being maintained by recharge from the river (see Figure 2).

Feather River. Ground water levels on the east side of the Feather River in Butte County declined as much as 4.5 metres (15 feet) between the spring measurements of 1975 and 1977. On the west side, declines generally were less than 2 metres (6 feet). In Sutter and Yuba Counties, declines were generally 2 to 3 metres (6 to 10 feet) on both sides of the river, except in an area south of the Bear River, where the decline was about 6 metres (20 feet). The water table generally sloped away from the river, indicating a possible loss of river-flow to the adjacent ground water basin (see Figure 2 and Plates 6 and 7).

Overall Ground Water Conditions

Ground water levels in the Sacramento Valley fluctuate considerably during the year. Normally, the peak levels occur in March or April after fall and winter precipitation and runoff have recharged the ground water basin. The low levels generally occur in July or August, after ground water has been withdrawn to help meet irrigation requirements.

During the past two drought years, peak water levels have occurred earlier in the water year and at much lower elevations. These two conditions reflect the lack of normal recharge of the ground water basin after it has been drawn down for irrigation. Plate 8 shows fluctuations in water levels for selected wells that typify seasonal changes in water levels for the basin since 1968. The wide fluctuations shown for Well No. 9N/2E-16N1, in Yolo County, are typical for wells withdrawing water from confined zones.

From the limited data available, it was impossible to accurately estimate the rates of loss from the rivers to the ground water basin.

Chapter III. WATER USE

Water utilization includes uses of water by nature or by people, either consumptive or nonconsumptive, and losses of water incidental to those uses. The term "diversions" means the gross amounts of water taken from the river channel as measured at the point of diversion.

In the Delta, water is served to the islands through innumerable siphons, culverts, and pumping plants, or by percolation from adjacent channels that cannot be accurately measured. Therefore, consumption of water in the Delta service area was computed by multiplying land-use acreages by appropriate unit evapotranspiration (ET) factors, as discussed in the appendix.

The procedures for computing water use in 1977 were essentially the same as the procedures used in 1976. Minor modifications were made as a result of changing conditions and new information developed in the 1977 survey.

Diversions Upstream from Sacramento

Surface diversions from the Sacramento, Feather, and Yuba Rivers are shown in Tables 8, 9 and 10. The smaller unmeasured diversions were computed from electric power records obtained from the power companies. The larger diversions along the Sacramento River, which amounted to 88 percent of the total water diverted, were measured by the USBR. The Department measured the major diversions from the Feather River.

Early in 1977, the USBR requested each water contractor along the Sacramento River to reduce river diversions by 25 percent of their total contract quantities. In May, on the basis of the February 1, 1977, forecast of water supply, the SWRCB notified riparian water users that unless they had a

Water diversion pump on the Sacramento River

contract with some water agency to provide them with water, they should restrict their water use to 60 percent of the amount normally diverted in June, 45 percent in July, and 50 percent in August.

As a result of these notices and the drought, many river diverters drilled wells to supplement the deficient river supply. Some wells are believed to receive a significant amount of replenishment from the surface streams. However, insufficient data were available to quantify the relative amounts drawn from the river and the ground water body.

During 1976 a field survey was made to identify the unmeasured smaller pumping plants along the Sacramento River between Shasta Dam and Sacramento, the Feather River below Oroville Dam, the Yuba River below the gaging station near Marysville, the Bear River below Wheatland, and the American River below "H" Street Bridge. No diversions were found along the latter two reaches. Since most small pumps are operated by electric motors, power consumption records provided the basis for estimates of diversions.

Monthly amounts of water diverted at the individual points are presented in Tables 8, 9 and 10. Diversions for the Sacramento and Feather Rivers have been segregated into stream reaches, defined by gaging stations at each end of the reach. Total monthly diversions in acre-feet within each reach are shown in Tables 8 and 9, and summarized in Tables 15 and 16. Table 10 is presented only for determining the net tributary inflow to the Feather River from the Yuba River.

Land Uses in Sacramento-San Joaquin Delta

Land-use surveys of the Sacramento-San Joaquin Delta service area were made in 1976 and 1977. Colored 35mm slides were taken from the air and viewed on a screen. The field boundaries and other land configurations were then delineated on USGS base maps. The types of crops and field boundaries were interpreted by specialists and noted by symbols on the maps. Field checks verified the photo interpretations.

The surveys covered the entire Delta service area, both "lowlands" and "uplands". The lowlands are those lands generally below the 1.5 metre (5-foot) elevation above mean sea level. The uplands lie outside of the lowlands and are served by irrigation water for the most part diverted from Delta channels. Lands that lie outside of the Delta lowlands and that are served by diversions from below the lowest gaging stations on streams flowing to the Delta are also considered as Delta uplands. The boundary of the Delta service area is shown on Plate 2. Areas of the various types of irrigated and nonirrigated crops, native and riparian vegetation, water surfaces, and other nonagricultural areas are shown in Table 12.

Consumptive Use of Water

Unit consumptive use factors for agriculture are determined by experimental investigations and by measurements of water in irrigated areas. Unit values of consumptive use are generally used for long-range water resource planning, and are therefore those that would occur under average conditions of water supply and climate. Values that have previously been used would not necessarily be applicable to a dry year such as 1977. Unit values given in the 1976 Sacramento Valley Water Use Survey report were reviewed and modified to reflect 1977 conditions. Although the monthly consumptive use varied significantly from the 10-year average, the annual values were not significantly different. Regardless of this similarity, it should be noted that irrigation demands from streamflows are substantially higher during the drought, because irrigation water must be substituted for rainfall normally contributing to the soil moisture.

Table 11 presents the modified monthly unit consumptive use factors for crops, nonagricultural vegetation, urban areas, and evaporation from water surfaces in the Delta service area. These unit factors, when applied in corresponding areas of land use in the Delta, provide an estimate of the water consumed. A more detailed explanation of the work done in developing the unit use factor is given in the appendix of this report.

"Consumptive use" as used herein is synonymous with "Evapotranspiration". The total volume of water derived from rainfall is considered as having been available for use in the Delta as one of the sources of water supply (see Tables 12 and 17). The total rainfall in a particular month was assumed to be fully used during

that same month, either by the crop or as a contribution to soil moisture. This rainfall, being low, did not contribute to surface runoff. Table 12 presents total monthly consumptive use for the March through October period.

Leaching and Preirrigation

In the Delta it is common practice to periodically leach and preirrigate the land by flooding after the crops have been harvested. On August 25, 1977, an aerial survey showed that about 1 000 hectares (2,400 acres) were flooded. A field check on September 15 showed only about 400 hectares (1,000 acres) flooded. On November 23 an aerial survey showed about 14 000 hectares (35,000 acres) flooded.

Exports from Delta

Normally, exports are made from the Delta by the Department for the State Water Project, by the USBR for the Central Valley Project, and by the City of Vallejo. During 1977, additional exports were made to East Bay Municipal Utility District (EBMUD), the City of San Francisco, and Marin County.

The State Water Project diverts water from Old River via Clifton Court Forebay and the Delta Pumping Plant to the California Aqueduct. The Central Valley Project diverts water from Old River via the Tracy Pumping Plant to the Delta-Mendota Canal and from Rock Slough via a pumping plant to the Contra Costa Canal. The City of Vallejo pumps water from Cache Slough. These diversion locations are shown on Plate 2.

During 1977 a pumping plant was installed on Middle River to provide an emergency supply of water for the Bay area. Water was pumped into the existing Mokelumne River Aqueduct of EBMUD for use in a portion of the EBMUD service area and also for use by the Contra Costa County Water District. Additional information is given in the Department's report, "The Continuing California Drought", under the heading, "Water Exchanges", beginning on page 85. The location of the emergency facilities is shown on Figure 4 of that report.

Salinity Control

The extent of salinity intrusion into the Delta is related to the rate and time of occurrence of Delta outflow and can therefore be controlled by freshwater outflow in sufficient quantities to counteract salinity intrusion.

Historically, outflow from the Delta has often been insufficient to prevent harmful salinity intrusion in the western Delta. Since the construction of the Central Valley Project and the State Water Project, releases of stored water have effectively restrained such intrusion.

In 1975, ocean salinity was almost completely repelled from entering the Delta. As shown on Plate 9, the maximum intrusion of 1 000 milligrams per litre chloride concentration was almost 5 kilometres (3 miles) downstream from Antioch. The monthly average computed Delta outflow to repel ocean salinity during the irrigation season ranged from 1 900 cubic metres per second (66,000 cubic feet per second) in March down to 270 cubic metres per second (9,500 cubic feet per second) in August (see Table 13). During the summer (June through September), the average computed Delta outflow was 400 cubic metres per second (14,200 cubic feet per second). This amounts to 4 400 cubic hectometres (3,500,000 acre-feet). The quality of the water in the Delta was better than required by water quality objectives established by the SWRCB.

In 1976 the maximum intrusion of the 1 000 milligrams per litre chloride concentration during the irrigation

season moved upstream about 15 kilometres (9 miles) to approximately Emmaton on the Sacramento River and Blind Point on the San Joaquin River (see Plate 9). The quality was essentially in compliance with objectives established for a dry year by the SWRCB. The computed Delta outflow ranged from a maximum of 266 cubic metres per second (9,400 cubic feet per second) in January, to 93 cubic metres per second (3,300 cubic feet per second) in September. The average outflow for the four summer months was 103 cubic metres per second (3,650 cubic feet per second). This amounts to 1 080 cubic hectometres (876,000 acre-feet).

On December 1, 1976, Sacramento Valley reservoirs were at relatively low levels. Carryover storage, which a year earlier had been 11 600 cubic hectometres (9.4 million acre-feet) was at 6 500 cubic hectometres (5.3 million acre-feet).

With precipitation substantially less than normal, it was apparent that large quantities of stored water would be required to control salinity intrusion. However, this same water was needed for other uses in other areas.

Prompted by the severity of the water shortage, the SWRCB held a special hearing on January 20 and 21, 1977, to consider a relaxation of quality objectives for the Delta. As a result of these hearings, an interim water quality control plan for 1977 was developed to conserve the limited water supplies and to help spread the burden of the critically dry year. Details of the plan were published in an SWRCB report, "Interim Water Quality Control Plan for 1977, Sacramento-San Joaquin Delta and Suisun Marsh", dated February 1977.

With the increased severity of the drought, stored water was being depleted at an alarming rate to satisfy even the interim water quality objectives. As a result, the SWRCB adopted emergency regulations on June 2, 1977, further relaxing the water quality objectives and allowing further reductions in Delta outflow. The resultant intrusion of ocean salinity moved the maximum 1 000 milligrams per litre chloride concentration to a point near Rio Vista on the Sacramento River and Jersey Point on the San Joaquin River, as shown on Plate 9. The computed Delta outflow (Table 13) ranged from 140 cubic metres per second (4,900 cubic feet per second) in February, to 59 cubic metres per second (2,100 cubic feet per second) in June. The average for the summer months was 74 cubic metres per second (2,600 cubic feet per second) or 784 cubic hectometres (635,000 acre-feet).

Water supply conditions to provide for Delta outflow greatly improved with storms in December 1977 and January 1978. Following these storms, a special hearing was held by SWRCB on February 2, 1978, and the emergency regulations were repealed.

Monthly maximum and same-day minimum chloride concentrations are listed in Table 14 for nine western Delta salinity observation stations.

Chapter IV. INVENTORY AND ANALYSIS

Data on water supply, water utilization, and water rights have been condensed into summary tables and charts for study and analyses in Tables 15 through 22.

Inventory of Water Supply and Use - 1977

An inventory of the source and disposition of the water supply of the major streams in the Sacramento Valley and of the Delta were compiled for 1977 conditions. Some elements of the inventory, such as surface stream and return flows and diversions were directly measured. Other elements, such as ground water and Delta consumptive use, were estimated.

Sacramento River

Table 15 summarizes monthly streamflow, diversions, and unmeasured accretions along the Sacramento River between Shasta Lake and Sacramento, along with computed inflow to Shasta Lake and the change in storage. The items, "Computed Inflow" and "Change in Storage", were taken from Table 5. Computed inflow was developed by the USBR from data on storage, release, precipitation, and evaporation.

Releases from Shasta Lake enter Keswick Reservoir for reregulation and are augmented by imports from the Trinity River Division of the Central Valley Project, which enter Keswick Reservoir through Spring Creek Power Plant. Flows from the Feather and American Rivers are considered as tributary inflows in the last two reaches near Sacramento. Diversions from the Feather River below Nicolaus were included in the diversions for the reach, Knights Landing to Verona. Total diversions and accretions for the entire river from Keswick to Sacramento are shown at the end of Table 15.

Feather River

Table 16 summarizes monthly streamflow, diversions, and accretions along the Feather River from Lake Oroville to Nicolaus and the computed inflow and change in storage for Lake Oroville. Items relative to operation of Oroville-Thermalito complex were taken from Table 5.

The complex of Thermalito Forebay, Afterbay, and Diversion Dam, together with their release and diversion facilities between Oroville Dam and the Thermalito Afterbay Release, was considered to be the first reach along this river system. Flows from Kelley Ridge power plant enter this reach below Oroville Dam. Several large diversions, including Sutter Butte and Western Canals, divert water from Thermalito Afterbay. The release to the Feather River from Thermalito Diversion Dam is considered to be an outflow from this reach and an inflow to the following reach. Flows from the Yuba and Bear Rivers are considered as tributary inflows in the last two reaches.

Sacramento-San Joaquin Delta

Table 17 summarizes water supply and water use of the Delta service area during March through October 1977. The Delta tributary inflow was obtained from Table 6, and the volume of precipitation was obtained from Table 1. The amounts shown under the heading, "Urban Requirement Imported or from Wells" were assumed to be supplied from sources other than Delta channels.

Under the heading "Water Use", monthly quantities of consumptive use in the Delta service area, exportations from Delta channels, and change in soil moisture are presented. The total

consumptive use was obtained from Table 12. Total exports were obtained from Table 6.

The 1977 monthly soil moisture gains and losses in the Delta were estimated from past studies by the Department, modified by the land and water use analysts to reflect, in their judgment, the 1977 conditions. The maximum soil moisture in the Delta lowlands was considered to be 250 millimetres of water per metre (3 inches per foot) of rooting depth. Maximum soil moisture in the Delta uplands is one-half that of the lowlands. The minimum soil moisture was nearly zero. This minimum limit of soil moisture was considered to occur when lands were either non-cropped or were in dry farmed crops. In general, water from precipitation and channel seepage supply soil moisture during spring, and crops deplete the soil moisture during summer.

Channel seepage is assumed to be 25 millimetres of water per metre (0.3 inches per foot) of rooting depth for the Delta lowlands only. While channe seepage cannot be measured, this is believed to be a reasonable assumption

Under the heading "Computed Surface Outflow" are the monthly quantities obtained by subtracting water use from water supply. These residual flows are estimates of the net amounts of fresh-water outflow from the Delta at its western extremity. The computed average monthly rate of flow is also presented.

Total consumptive use in the Delta service area (Table 12) for the period March through October 1977, amounted to 2 125 cubic hectometres (1,722,000 acre-feet). This figure is 1 percent lower than the total use for the same period during 1976.

Irrigation of Safflower

Monthly Diversions and Accretions

Table 18 and Plate 10 compare 1977 diversions above Sacramento with diversions for the 5-year period 1972-1976, thus enabling a comparison of diversion quantities and diversion patterns in recent years. The monthly diversions in percentage of total seasonal diversion are also shown in Table 18 to compare diversion patterns with those of prior years.

The percentage of normal runoff at Sacramento River at Sacramento is shown for comparison with the diversions for the season.

The diversions in April are higher in the drier years than in the normal or above normal years. Also, March would probably show higher diversions if comparative data were available. The reasons for the high March and April diversions in the dry years are to increase the soil moisture that was not supplied by rainfall and to irrigate crops planted earlier than normal. Table 18 shows that maximum monthly diversion occurred in May and June, while the irrigation pattern for earlier years presented in the Bulletin 23 series, "Surface Water Flow", shows July to be the maximum month of irrigation. With the exception of 1977, when deficiencies had to be taken, increased diversions are attributable in part to increased diversions via Corning Canal since 1961, and Tehama-Colusa Canal since 1966. Diversions to Tehama-Colusa Canal during March through October of 1977 amounted to 152 cubic hectometres (123,000 acre-feet).

Plate 10 shows a substantial reduction in the 1977 diversions, particularly during May, when rainfall was above normal and temperatures were below normal, resulting in a considerably reduced water demand. The seasonal total diversion was 74 percent of the 1976 diversion quantity.

Table 19 compares unmeasured accretions for the last 31 years of record. (Sufficient data were not available for 1970 and 1971 to enable reliable estimates of diversions and accretions.) These figures represent the total net unmeasured accretions between Sacramento and Keswick Dam and were computed as described in the first part of this chapter. The diversion quantities measured by the USBR for the years since 1963, the last year when all the diversions were measured, were revised to include an estimate of the unmeasured diversions. The increase was approximately 8 percent in most of the years; however, in some years, the increase was less than 5 percent of the measured diversions.

The total of the unmeasured accretions is the net result of all the computed gains or losses within the various river reaches. This quantity of water can be attributed to ground water movement to or from the river, since all surface flows have been measured or estimated. Also shown for purposes of analyses are: (1) runoff in percentage of normal for Sacramento River at Sacramento, and (2) total accretions for April through October and July through September. The July through September period is probably more indicative of the loss or gain between surface flow and ground water.

Plate 11 is a graphical analysis of the monthly data taken from Table 19. The graph shows that the average unmeasured accretions for 1976 and 1977 are below the 10-year averages of both dry and wet years.

Plate 12 is a graphical presentation of the decrease in total seasonal (April through October and July through September in Table 10) unmeasured accretions of the Sacramento River above Sacramento for all years except 1970 and 1971 since 1947.

Diversions during 1977 from the Feather River from Oroville Dam to the mouth amounted to a total of 762 cubic hectometres (617,900 acre-feet) for March through October. These diversions were 62 percent of the 1976 quantities. This quantity of water was diverted by a total of 76 individual points of diversion. Of the 76 points of diversion, there are 13 major diversion points that are measured each year by the Department. These 13 accounted for about 95 percent of the water diverted. Four points of diversion, which take water from Thermalito Afterbay, accounted for 83 percent of the total Feather River diversions.

The unmeasured accretions along the Feather River below Oroville Reservoir are presented in Table 16. The unmeasured accretion between Oroville Dam and Nicolaus for March through October 1976 was a gain of about 205 cubic hectometres (165,700 acre-feet) compared with a loss of 9 cubic hectometres (7,100 acre-feet) in 1977.

Interrelationship between Surface and Ground Waters

Efforts were made to analyze the direct relationship between the decline in unmeasured accretions and the decline in ground water levels. This interrelationship could not be quantified, but is discussed in general terms.

The large declines in ground water levels in the Sacramento Valley between 1975 and 1977 have resulted from two main factors: (1) decreased recharge because of low precipitation and surface flows and (2) increased extractions from the ground water supply to satisfy water demands normally met by surface supplies. In the spring of 1975, the ground water basin was essentially filled to its normal storage capacity. By spring 1977, stored ground water had been depleted by about 2 100 cubic hectometres (1,700,000 acre-feet).

In a sense, the increased use of ground water could be considered incidental conjunctive use of surface and ground water. Ground water served as a reserve supply in many areas to make up the difference between available surface water and the increased irrigation water required to sustain agricultural production during the drought.

The declines in ground water levels during 1976 and 1977 increase the possibility for percolation of streamflow to the ground water basin. Factors having the greatest influence on percolation would be the slope of the hydraulic gradient away from the river, the length of time the hydraulic gradient is sustained, and the permeability of the soils in the area.

Hydraulic Gradient and Duration

In March 1977, the slope of the hydraulic gradient from surface water to ground water immediately adjacent to the Sacramento River was not significantly different than in March 1975, because the river stage dropped along with the water table. The major change in hydraulic gradient was in the water table itself, which changed from an approximately flat slope in 1975 to a rather steep slope toward the pumping depressions in 1977 (see Figures 1 and 2).

Well hydrographs (Plate 8) showed that ground water levels continued to drop through the irrigation season, thereby increasing the slope of the hydraulic gradient away from the river. Decreases in unmeasured accretions to streamflow (see Plate 11) during the irrigation season, therefore, are attributable in part to percolation of streamflow.

With the progressive declines in water levels since 1975, a hydraulic gradient away from the river probably has been maintained for a much longer time than

it would be during normal years. This, along with the steeper hydraulic gradient toward the pumping depressions, would tend to increase the rate of ground water movement away from the river. The steepest landward hydraulic gradients occurred near Knights Landing, where losses in streamflow, as indicated by negative unmeasured accretions, were the greatest. A portion of these losses is due to percolation.

Some irrigation wells, if located in the highly permeable stream deposits near the river, may withdraw more water directly from the river than from the ground water basin. A detailed investigation is required to document the amount and time of travel of water from the river to wells and other movements between surface and ground water resulting from changing hydraulic gradients. Of particular importance is the collection of data that could be used in estimating the quantity of ground water recharged directly from the river.

Recharge of the Ground Water Basin

From a water supply standpoint, percolation of flow from the Sacramento River does not constitute a loss of water. The recharge to the ground water basin becomes available for beneficial use through wells or return flow to the system. Other major sources of recharge are precipitation and applied water. During 1976 and 1977 recharge from precipitation on the valley floor area was negligible.

The ground water basin generally receives variable quantities of recharge through percolation of applied irrigation water. Under normal conditions, about 65 percent of all irrigation water is consumptively used by plants for vegetative growth. The remaining 35 percent percolates, evaporates, or runs off. Depending on the soil, about 10 to 25 percent of the irrigation water percolates into the ground water basin.

When water supplies are deficient, farmers undoubtedly irrigate more efficiently, and less than the normal portions of applied water percolate into the ground water basin. Much less excess water was probably applied intentionally to meet leaching requirements of irrigated crops.

Water Entitlements

In the spring of 1977, the SWRCB, in cooperation with the Department and the USBR, made forecasts of the extent to which water would be available to satisfy existing water rights. Notices were sent to Sacramento and San Joaquin Valley water users who did not have contracts with the USBR or the State requesting their cooperation in limiting water use to the anticipated water supply.

Because of storms in May, the actual runoff of valley streams for May and June was higher than had been forecast. Table 20 compares the percentages of water available to satisfy normal demands under various forecasts and actual measurements and the percentages of normal demand of water used by crops. As indicated in the table, the assumed riparian use based on 1977 conditions was lower than the water supply available to satisfy riparian rights through June, but exceeded the supply in July and August. An overview study was made to quantify the amounts of water diverted for assumed riparian use in excess of the estimated nonproject runoff. The results of the study are summarized in Table 21.

Many assumptions were necessary in making the study. Three of the most significant were: (1) the nonproject runoff was used to satisfy riparian rights before water was made available for other rights, (2) all Delta lowlands and 12 500 hectares (31,000 acres) of the uplands were assumed to have riparian water rights, and (3) for various calculations in this survey, Delta outflow required to

* *"Evaluation of Ground Water Resources: Sacramento County", DWR Bulletin 118-3, July 1974.*

satisfy the 1977 emergency conditions was considered to have rights analogous to riparian rights.

Nonproject Water Supply

The actual recorded outflows of foothill reservoirs were modified by eliminating the effect of projects. Estimated contributions and losses occurring between the foothill reservoirs and the Delta were added to or subtracted from the modified reservoir outflows. The resulting figures are the estimated nonproject runoff available to satisfy riparian rights. They include the flows of Sacramento River at Keswick, the Feather River at Oroville, the Yuba River at Englebright Dam, and the American River at Fair Oaks. A cursory review of the unimpaired runoff and riparian use of the San Joaquin River system was also made. The actual recorded flow at Vernalis was used in the table because significant unimpaired runoff to the Delta occurs only through June.

Assumed Riparian Land and Water Use

The assumed riparian land along the Sacramento River was determined from information provided by USBR. Water diverted by assumed riparian users was computed in two categories; those users who have contracts for water from USBR, and the remaining diverters. According to USBR, practically all of the water users along the Sacramento River who do not have a contract for project water claim riparian rights. The water diverted by these users was estimated from electric power records and assumed to be riparian. Added to this assumed riparian use was an amount of water estimated from information furnished by USBR for use on assumed riparian lands by users who have USBR contracts. An estimate of the riparian use on the Feather, Yuba, and American Rivers was made from information provided by the SWRCB. Actual data from assumed riparian use on these rivers were not available. In the Delta, the extent of riparian rights was based on reports prepared by the USBR entitled "Central Valley Project - Delta Lowlands Service Area Investigation", dated January 1964, and "Central Valley Project - Delta Uplands Service Area Investigation", dated January 1963.

All of the Delta lowlands and 12 500 hectares (31,000 acres) of the Delta uplands were assumed to have riparian rights. However, questions have been raised on whether or not the south Delta has riparian rights to water from the Sacramento River system during July and August of a critical dry year such as 1977, because only a limited amount of water would have flowed across the Delta under natural conditions. The south Delta is generally assumed to have been riparian to the San Joaquin River at least under natural conditions. No special investigations into the status of assumed riparian rights were made under the Sacramento Valley Water Use Survey.

The water use shown for Delta agriculture and Delta water surface, riparian and native vegetation, and urban development was obtained from a computer program operated by the Division of Planning. The use was computed by multiplying crop data collected in 1977 and a unit water use figure adjusted for assumed soil moisture contribution.

Since 1944 project water has been used to repel salinity in the Delta during the summer months. Delta outflow, along with many other Delta water uses, is considered to have riparian rights. Many assumptions can be made in computing the amount of water that has been released to limit salinity intrusion. Table 13 shows the monthly computed amounts of Delta outflow for each year from 1965 through 1977. The table is included to show the magnitude of Delta outflow in the various years.

As indicated in Table 21, the nonproject runoff to satisfy assumed riparian rights was deficient during July and

August. The water deficiencies in nonproject runoff within the Sacramento Valley and the Delta within these months was estimated to be approximately 360 cubic hectometres (290,000 acre-feet). The deficiencies were assumed to be supplied from stored water from the State Water Project and the Central Valley Project. The water was used for Delta outflow and for Delta agriculture. More detailed studies and information on specific water rights would be required to identify the extent of excess use by assumed riparian users on an individual basis.

Table 22 is similar to Table 21, except for different assumptions. In Table 22, Delta outflow and consumptive uses in the Delta other than for agricultural (evaporation from water surfaces, water uses by riparian and native vegetation) were considered to be losses that must be satisfied before other riparian rights. Also, Table 22 is based on a full supply (1976) for assumed riparian rights and, using Table 17, Delta outflow quantities for salinity control. Based on these assumptions, the percent of normal water supply for crops on assumed riparian land during 1977 would have been 95, 29, 30 and 100 for the months June through September, respectively.

Tables 21 and 22 show that all of the nonproject runoff was needed by assumed riparian rights during the months of July and August. Assumed riparian water users diverting from the Sacramento River upstream from Sacramento reduced their diversions about 25 percent of their full demand during June, July, and August. Because of these reductions, sufficient nonproject runoff was available to satisfy actual diversions under assumed riparian rights during June. Only a small amount of water was available for appropriative rights during June, and none was available during July and August. Those appropriators who had contracts for water from the Central Valley Project and the State Water Project were assumed to be diverting stored water in accordance with their contracts during these summer months.

Unauthorized Diversions

From the information collected under the Sacramento Valley Water Use Survey, it was concluded that unauthorized diversions from the main stem of the Sacramento River upstream from Sacramento and from the Feather River was less than 1 percent of the total diversions because contracts were in force for the use of project water to supplement riparian and appropriative water rights. Detailed studies were not made of diversions from the Colusa Basin Drain and other channels tributary to the Sacramento River system. The Sutter Bypass was investigated by the SWRCB and its findings were reported in a report titled "Sutter Bypass, Report on Use of Water During the 1977 Irrigation Season", by Mike Golden, Associate W.R.C. Engineer, under the direction of David Sabiston, Supervising Engineer.

The USBR claims a right to Central Valley Project return flows and alleged that much of the water diverted from the Colusa Basin Drain and some other tributary channels during June, July, and August was return flow from project water and was being diverted without authorization.

In the Delta, except for an interim agreement between the Department and the North Delta Water Agency, uses of project water were not authorized. Based on studies made to develop Table 21, the diversions of project water amounted to about 360 cubic hectometres (290,000 acre-feet) by the assumed riparian water users during July and August primarily in the Delta lowlands, and about 165 cubic hectometres (135,000 acre-feet) by appropriators in the Delta uplands during June, July, and August. It should be recognized that no measurements of diversions were made in the Delta. Estimates of unauthorized diversions were made from estimates of water use based on the crops grown during 1977.

DEFINITIONS

Accretion - Surface and ground water inflows to a reach of a stream.

Appropriative Water Right - A water right which is not derived from the ownership of land abutting a water source but which derives from applying the water to beneficial use.

Assumed Riparian Water Use - A use of water under a claim of a riparian water right that has not been verified by title search or by court decision.

Chloride Concentration - See "Salinity Intrusion".

Confined Ground Water - A body of ground water overlain by material sufficiently impervious to sever free hydraulic connection with all overlying ground water except at the upper edge of the confining stratum where the confined water connects with free ground water. Confined ground water moves in strata, conduits or arteries under the control of the difference in head between the intake and discharge areas of the confined water body.

Consumptive Use - See "Evapotranspiration".

Diversion - Taking water from a stream or other body of water into a canal, pipeline, or other conduit.

Drainage - Removal of surface or ground water from a given area by gravity or by pumping.

Evapotranspiration (ET) - The quantity of water transpired by plants, retained in plant tissues, and evaporated from adjacent soil surfaces in a specified time period. Usually expressed in depth of water per unit area.

Exports - Water diverted from Delta channels and conveyed to areas outside of the Delta service area.

DEFINITIONS

Free Ground Water - Water moving through an interconnected body of pervious material unhampered by impervious confining material, and moving under control of the water table slope.

Impairments - Man-made adjustments to the natural flow.

Leach Water - Water used to flood land for the maintenance of soil salinity.

Lysimeter (Evapotranspirometer) - A device used to measure the evapotranspiration of a crop.

Native Vegetation - Lands that have not been cultivated during the past 3 years; i.e., roadways, levees, barren lands, etc.

Nonproject Runoff - Water quantities that flowed in the Survey Area stream channels that were not provided by the State Water Project, Federal Central Valley Project, or other significant storage, import or export projects.

Percolation - Flow of ground water in streamline flow in any direction through the ground.

Potential Evapotranspiration (PET) - The amount of water that can be transpired by low growing green crop of about the same color as grass, which completely covers the ground, has an unlimited supply of water and an extensive area of similar ground cover.

Precipitation - Total measurable water supply from all forms of falling moisture during a specified time.

Return Flow - Diverted water which is not taken by consumptive use and finds its way back to the original source by surface drainage or percolation.

Riparian Vegetation - Vegetation growing along back of streams and sloughs, and in marsh and meadowland naturally occupied by phreatophites as the dominant vegetation; i.e., tules, willows, and water lilies.

DEFINITIONS

Riparian Water Right - Legal right which assures to the owner of land abutting a stream or other natural body of water the use of a share of such water.

Salinity Intrusion - Relative concentration of chlorides in water expressed in milligrams per litre (mg/l), caused by tidal action mixing the more salty water of the bays or ocean with fresh water flowing toward the ocean.

Seepage - Slow movement of water through small cracks or pores of unsaturated material into or out of a body of water.

Unimpaired Runoff - The runoff that would occur if there were no storage or diversions along a stream.

Water Balance - Balancing the flow in a reach of a channel by equating the inflow and return flow to the outflow, diversions, and unmeasured accretions.

Water Contractors - Water users who have contracts for a supplemental water supply from either the Federal Central Valley Project or the State Water Project.

Water Entitlement - Water that a person is entitled to use on a parcel of land as the result of the exercise of the various types of water rights.

Water Utilization - Uses of water by nature or man, either consumptive or nonconsumptive, including water losses incidental to that use.

Wetness Index - Percent of average annual unimpaired runoff.

TABLE 1

MONTHLY PRECIPITATION

Sacramento Valley and Delta

January through October - 1977

Station		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
		Inches									
SACRAMENTO VALLEY											
Shasta Dam	1977	3.31	2.48	2.96	1.26	5.34	0.03	0.01	0.27	8.89	1.87
	Normal	11.28	8.45	7.94	4.51	2.15	1.45	0.22	0.20	0.41	3.45
Redding Fire Station 2	1977	3.00	1.75	2.51	0.34	4.40	0.03	0.02	0.13	7.94	0.74
	Normal	7.97	5.77	4.76	2.93	1.47	1.00	0.16	0.20	0.54	2.21
Red Bluff Airport	1977	2.70	1.35	1.37	0.98	3.29	0.45	0.35	1/	1.26	0.13
	Normal	4.27	3.11	2.49	1.63	0.91	0.44	0.04	0.12	0.35	1.29
Orland	1977	2.25	1.03	1.69	0.59	3.16	0.05	0.07	0.04	0.57	0.04
	Normal	4.07	3.30	2.63	1.51	0.60	0.37	0.04	0.13	0.28	1.14
Oroville	1977	2.17	1.62	1.12	0.62	1.60	0.00	0.00	0.00	0.72	0.09
	Normal	5.75	4.64	4.03	2.25	0.97	0.37	0.04	0.07	0.30	1.54
Colusa	1977	3.10	1.04	1.35	0.70	1.66	0.00	1/	0.00	0.49	0.27
	Normal	3.12	2.37	1.80	1.05	0.37	0.20	0.07	0.08	0.18	1.06
Marysville	1977	1.80	1.36	1.01	0.04	1.47	0.00	0.07	0.02	0.72	0.40
	Normal	3.99	3.48	2.62	1.64	0.62	0.25	0.05	0.06	0.21	1.27
Woodland	1977	1.59	1.07	2.05	0.04	1.43	0.00	0.00	0.00	0.50	0.44
	Normal	3.57	2.95	2.11	1.32	0.46	0.16	0.04	0.03	0.17	0.93
Folsom Dam	1977	1.39	1.12	1.21	0.07	1.65	0.00	1/	0.00	0.46	0.18
	Normal	4.68	3.99	3.45	1.96	0.84	0.23	0.05	0.04	0.20	1.31
Sacramento	1977	1.36	1.10	1.33	0.36	1.02	0.00	0.01	0.00	0.55	0.25
	Normal	3.47	3.22	2.41	1.51	0.48	0.14	0.02	0.05	0.20	0.93

Records for 1977 precipitation were obtained from California Department of Water Resources (DWR) Snow Surveys. Monthly normal precipitation is DWR Snow Survey Record for base period 1931-1975, except Colusa which was calculated from the 21-year period 1954-1975.

1/ Trace.

Metric Conversion: Inches times 25.4 equals millimetres.

TABLE 1 (Cont'd.)

MONTHLY PRECIPITATION

Sacramento Valley and Delta

January through October - 1977

Station		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
		Inches									
DELTA SERVICE AREA											
Galt	1977	1.08	1.14	1.05	0.01	1.54	0.00	0.00	0.00	0.49	0.25
	Normal	3.22	2.87	2.42	1.39	0.50	0.12	0.02	0.03	0.19	0.84
Davis	1977	1.34	0.89	1.83	0.01	1.12	1/	1/	0.00	0.71	0.23
	Normal	3.58	3.01	2.12	1.26	0.45	0.15	0.02	0.02	0.15	0.93
Lodi	1977	1.24	1.19	1.63	0.12	1.43	0.00	0.00	0.00	0.39	0.16
	Normal	3.15	2.68	2.36	1.40	0.48	0.12	0.03	0.04	0.20	0.92
Stockton Fire Station 4	1977	1.06	0.91	1.06	0.04	1.39	0.00	0.00	0.00	0.34	0.06
	Normal	3.00	2.88	2.54	1.30	0.47	0.11	0.02	0.03	0.17	0.75
Rio Vista	1977	1.29	1.04	1.50	1.03	1.21	0.25	0.00	0.00	0.92	0.12
	Normal	3.44	2.75	2.25	1.31	0.42	0.14	0.02	0.05	0.13	0.83
Brentwood Corporation Yard	1977	0.69	0.58	1.13	0.23	1.87	0.00	0.00	0.00	0.26	0.00
	Normal	2.61	1.94	1.48	1.14	0.21	0.08	0.01	0.14	0.22	0.73
Tracy Carbona	1977	0.84	0.38	0.58	0.12	1.93	0.00	0.05	0.00	0.41	0.19
	Normal	1.91	1.66	1.41	0.80	0.34	0.06	0.06	0.07	0.12	0.47
AVERAGE DELTA SERVICE AREA PRECIPITATION 2/											
Weighted Average 2/ Inches:	Uplands	1.00	0.70	1.12	0.15	1.60	0.02	0.02	0.00	0.49	0.16
	Lowlands	1.10	0.89	1.30	0.48	1.43	0.10	0.00	0.00	0.61	0.13
Monthly Total Acre-feet:	Uplands	17,682	12,378	19,804	2,652	28,292	354	354	0	8,664	2,829
	Lowlands	42,716	34,561	50,482	18,652	55,530	3,883	0	0	23,688	5,048
	Totals	60,578	46,939	70,286	21,292	83,822	4,237	354	0	32,352	7,877

Precipitation and Normal for 1977 is from DWR Snow Surveys records for base period 1931-1975, except Brentwood Corporation Yard, which is from Contra Costa County records.

1/ Trace.

2/ Thiessen Balance Method.

Metric Conversion: Inches times 25.4 equals millimetres.
Acre-feet times 1233.5 equals cubic metres.

TABLE 2

ANNUAL UNIMPAIRED RUNOFF

In Percent of Average

	Sacramento and San Joaquin Rivers to Delta (1)	Sacramento River near Red Bluff	Sacramento River at Sacramento (1)	Feather River near Oroville	Yuba River at Smartville	American River at Fair Oaks	Mokelumne River near Mokelumne Hill	San Joaquin River near Vernalis (1)
Average Annual Runoff (2)	23,809	7,948	17,082	4,287	2,274	2,573	705	5,455
1923-24	31	41	33	29	26	20	25	26
1930-31	33	41	35	33	28	26	28	29
1933-34	48	57	51	47	43	44	42	42
1934-35	101	94	97	100	99	100	100	118
1935-36	106	89	102	100	114	132	127	119
1936-37	88	75	78	74	82	90	99	120
1937-38	189	185	186	201	177	175	176	206
1938-39	48	55	48	43	40	41	48	53
1939-40	128	132	131	132	126	132	122	121
1940-41	152	180	159	151	138	122	119	145
1941-42	143	142	148	155	150	152	140	135
1942-43	126	107	124	131	138	151	143	135
1943-44	63	59	61	67	61	57	63	72
1944-45	82	84	88	87	93	98	110	121
1945-46	102	101	102	98	106	111	106	105
1946-47	60	64	61	59	60	55	56	63
1947-48	88	96	92	90	88	87	90	77
1948-49	69	76	70	61	65	72	73	70
1949-50	85	72	85	90	98	104	107	85
1950-51	135	114	134	133	156	180	165	133
1951-52	168	145	167	186	181	193	188	171
1952-53	107	122	118	122	112	103	97	80
1953-54	94	117	102	99	84	78	75	79
1954-55	64	71	64	58	57	61	62	64
1955-56	174	167	175	186	174	181	177	179
1956-57	84	90	87	85	86	83	85	79
1957-58	167	190	174	163	155	159	151	153
1958-59	65	85	71	67	54	48	53	53
1959-60	70	81	76	75	75	65	59	54
1960-61	61	90	70	62	50	41	40	38
1961-62	91	94	88	85	85	80	91	103
1962-63	128	125	135	146	144	138	124	114
1963-64	62	66	64	60	65	63	61	58
1964-65	150	130	150	162	171	174	170	148
1965-66	74	92	76	67	63	54	65	73
1966-67	150	132	141	147	145	154	162	183
1967-68	72	87	80	81	69	66	58	54
1968-69	173	148	157	165	161	166	189	225
1969-70	130	147	140	142	128	123	126	103
1970-71	121	136	133	144	126	116	111	89
1971-72	74	83	79	75	75	73	73	65
1972-73	117	121	118	113	117	117	111	118
1973-74 (3)	172	200	189	190	172	165	143	130
1974-75 (3)	110	116	111	113	100	100	110	113
1975-76 (3)	44	61	48	43	30	31	33	35
1976-77 (3)	27	43	30	24	15	14	19	19

(1) Figures were computed from summations of unimpaired runoff at foothill stations on major tributaries only and do not include runoff from minor tributaries and from valley floor.

(2) Average unimpaired runoff in thousands of acre-feet computed from the 50-year period October 1920 through September 1970.

(3) Preliminary data subject to revision.

Metric Conversion: Thousands of acre-feet times 1.2335 equals cubic hectometres.

TABLE 3

MONTHLY UNIMPAIRED RUNOFF (1)

1976-77 WATER YEAR
In Percent of Average

		Sacramento and San Joaquin Rivers to Delta(2)	Sacramento River Near Red Bluff	Sacramento River at Sacramento (2)	Feather River Near Oroville	Yuba River at Smartville	American River at Fair Oaks	Mokelumne River Near Mokelumne Hill	San Joaquin River Near Vernalis (2)
October 1976	Percent	84	103	87	67	34	69	41	58
	Average	512	292	460	107	35	25	5	46
November 1976	Percent	47	66	52	43	34	15	14	20
	Average	896	425	752	171	81	76	17	118
December 1976	Percent	19	33	22	18	5	2	4	6
	Average	1,938	837	1,618	380	202	199	39	253
January 1977	Percent	20	28	22	20	13	8	8	11
	Average	2,476	1,106	2,082	464	247	265	45	300
February 1977	Percent	15	20	16	17	6	8	12	11
	Average	2,935	1,275	2,416	541	287	313	56	400
March 1977	Percent	19	29	20	17	11	12	14	12
	Average	2,952	1,093	2,313	576	296	348	72	501
April 1977	Percent	20	25	19	14	17	17	28	23
	Average	3,628	1,006	2,569	721	383	459	127	864
May 1977	Percent	24	49	28	19	20	19	22	18
	Average	3,935	684	2,286	658	425	519	195	1,409
June 1977	Percent	32	62	36	29	17	20	21	27
	Average	2,468	435	1,262	331	219	278	121	1,069
July 1977	Percent	38	80	57	50	20	2	7	9
	Average	965	298	569	153	55	65	22	370
August 1977	Percent	70	97	81	62	0	0	42	21
	Average	488	251	394	102	24	16	4	89
September 1977	Percent	102	128	110	68	47	0	54	23
	Average	400	247	361	85	20	10	2	36
October 1977	Percent	69	96	75	51	0	19	17	15
	Average	512	292	460	107	35	25	5	46
1976-77 Water Year (3)	Percent	27	43	30	24	15	14	19	19
	Average	23,593	7,948	17,082	4,287	2,274	2,573	705	5,455

(1) Average unimpaired runoff in thousands of acre-feet computed from the 50-year period October 1920 through September 1970.
(2) Figures were computed from summations of unimpaired runoff at foothill stations on major tributaries only, and do not include runoff from minor tributaries and from the valley floor.
(3) For entire water year (12-month period).
Metric Conversion: Thousands of acre-feet times 1.2335 equals cubic hectometres.

TABLE 4

SACRAMENTO BASIN RESERVOIR STORAGE[1/]

1975 - 1977

(All Quantities in Acre-Feet)

Stream System	Agency	Reservoir	Capacity	Water in Storage		
				Dec. 1, 1975	Dec. 1, 1976	Dec. 1, 1977
Sacramento	USBR	Whiskeytown	241,000	201,800	201,800	212,900
	USBR	Shasta	4,552,000	3,329,000	1,562,000	648,200
		Totals	4,793,000	3,530,800	1,763,800	861,100
Feather	PG&E	Mt. Meadows	24,800	5,410	0[2/]	30
	PG&E	Lake Almanor	1,308,000	821,553	574,598	519,900
	PG&E	Butt Valley	53,120	43,777	47,224	47,300
	PG&E	Bucks Lake	103,000	51,389	43,426	37,380
	DWR	Antelope	22,600	2,357	1,246[3/]	3,170
	DWR	Frenchman	55,500	25,439	14,279	7,770
	DWR	Lake Davis	84,400	71,644	58,841	33,600
	DWR	Oroville	3,537,600	2,582,746	1,627,254	917,738
	Oroville-Wyandotte I.D.	Little Grass Valley	93,000	50,194	44,508	30,840
		Sly Creek	60,050	9,048	9,978	12,880
		Totals	5,347,070	3,663,557	2,421,354	1,610,608
Yuba	Brown's Valley I.D.	Merle Collins	57,000	38,000	14,500	5,300
	Yuba Co. Wtr. Agcy.	New Bullards Bar	969,000	389,707	284,665	233,160
	Nevada I.D.	Mountain Division[4/]	160,000	90,301	36,142	17,270
	Nevada I.D.	Scotts Flat	49,000	38,941	15,700	2,710
	PG&E	Lake Fordyce	46,660	4,002	5,404	4,471
	PG&E	Lake Van Norden	5,874	2,353	0[5/]	0[5/]
	PG&E	Spaulding	74,488	11,880	19,395	38,394
	Calif. Debris Comm.	Englebright	70,000	68,828	63,701	65,820
		Totals	1,432,022	644,012	439,507	367,125
Bear	So. Sutter Wtr. Dist.	Camp Far West	104,400	105,500	5,900	4,600
	N.I.D.	Rollins	66,000	60,378	6,500	19,230
	N.I.D.	Combie	9,000	5,555	1,259	1,726
		Totals	179,400	171,433	13,659	25,556
Cache Creek	Yolo Co. FCWCD	Clear Lake	420,000	75,000	- 19,000	10
	Yolo Co. FCWCD	Indian Valley	300,000	104,000	0	0
		Totals	720,000	179,000	- 19,000	10
American	Placer Co. W.A.	French Meadows	133,700	79,813	39,841	38,470
	Placer Co. W.A.	Hell Hole	208,400	148,148	94,093	73,300
	Georgetown P.U.D.	Stumpy Meadows	20,000	15,908	10,000	5,500
	SMUD	Loon Lake	76,500	55,242	7,784	17,940
	SMUD	Ice House	45,960	22,230	4,955	11,660
	SMUD	Union Valley	271,000	148,248	34,690	52,420
	SMUD	Slab Creek	16,600	13,860	15,600	15,500
	PG&E	Caples Lake	21,581	18,376	9,465	5,340
	PG&E	Silver Lake	11,800	3,574	428	604
	USBR	Folsom	1,010,000	630,200	393,700	147,000
		Totals	1,815,541	1,135,599	610,556	367,734
Stony Creek	USBR	East Park	50,900	3,186	2,378	2,790
	USBR	Stony Gorge	50,000	23,013	8,678	5,070
	C. of E.	Black Butte	160,000	26,200	11,600	1,610
		Totals	260,900	52,399	22,656	9,470
BASIN TOTALS			14,547,933	9,376,800	5,271,532	3,241,603

1/ Does not include power regulation reservoirs, afterbay regulation reservoirs, reservoirs less than 5,000 AF capacity, or reservoirs outside the basin which export some water into the basin.
2/ Evaporation loss, no draft in 1976.
3/ Dewatered for fish eradication.
4/ Includes six reservoirs in upper Yuba watershed: Jackson Meadows, French Lake, Faucherie, Bowman Lake, Sawmill, Catfish.
5/ Breached by PG&E.

Metric Conversion: Acre-feet times 1233.5 equals cubic metres.

TABLE 5

RESERVOIR OPERATIONS - 1977

	Acre-Feet							
	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
SHASTA LAKE								
Inflow (Computed)	245,440	200,060	223,320	195,410	180,100	197,000	235,960	231,090
Storage (End of Month)	1,460,700	1,214,100	1,127,100	937,700	680,500	578,000	630,600	656,000
Change in Storage	-24,900	-246,600	-87,000	-189,400	-257,200	-102,500	+52,600	+25,400
KESWICK RESERVOIR								
Inflow from Shasta	267,230	441,340	453,490	378,380	430,050	294,520	180,460	203,740
Import from Trinity Div.	71,010	44,880	152,930	176,240	227,390	224,620	95,790	16,300
Release	333,350	474,280	451,910	555,130	656,050	512,960	273,530	215,930
OROVILLE-THERMALITO COMPLEX								
Inflow (Computed)	74,315	60,553	72,229	46,701	42,763	98,419	100,448	61,231
Storage (End of Month)	1,564,494	1,406,826	1,353,410	1,202,953	996,872	891,820	915,160	905,324
Change in Storage	-7,917	-157,668	-53,416	-150,457	-206,081	-105,052	+23,340	-9,836
Release	80,072	213,780	122,103	191,043	242,113	197,801	72,828	67,892
Thermalito Diversion Dam Release to River	24,990	23,869	24,523	24,242	24,887	24,995	23,784	46,753
Thermalito Afterbay River Outlet	34,299	123,538	33,747	57,726	98,618	71,590	45,991	8,944
FOLSOM LAKE								
Inflow (Computed)	32,750	34,920	43,080	25,430	10,710	24,080	24,160	20,680
Storage (End of Month)	285,300	297,900	303,900	252,500	200,100	163,600	147,000	146,300
Change in Storage	+13,800	+12,600	+6,000	-51,400	-52,400	-36,500	-16,600	-700
LAKE NATOMA								
Inflow	16,880	17,770	32,570	68,530	56,100	53,710	31,220	16,560
Release to River	15,920	15,570	30,740	65,570	52,910	51,170	29,910	15,400

Metric Conversion: Acre-feet times 1233.5 equals cubic metres.

TABLE 6

MONTHLY FLOWS AT SURFACE WATER MEASUREMENT STATIONS - 1977

Station	Acre-Feet							
	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
Sacramento River								
At Keswick	333,800	480,200	456,900	568,400	665,300	522,900	271,600	211,000
Above Bend Bridge (near Red Bluff)	392,900	502,300	512,200	568,400	666,500	525,200	316,700	242,000
At Vina Bridge	403,200	502,400	520,200	536,400	631,100	517,400	290,300	228,600
At Hamilton City	354,100	381,900	441,000	432,900	523,800	398,500	259,800	204,600
At Ord Ferry	364,700	378,400	430,400	420,400	507,300	399,300	262,100	222,900
At Butte City	343,000	351,000	424,800	399,800	503,900	389,500	260,500	204,300
At Colusa	359,800	343,100	403,400	371,500	469,000	379,000	257,200	200,800
Below Wilkins Slough	316,800	263,000	352,700	296,400	391,200	321,200	241,900	204,700
At Knights Landing	348,700	261,200	372,100	290,500	389,800	356,400	287,000	216,400
At Verona	413,900	368,200	457,000	339,500	462,900	425,000	374,900	290,500
At Sacramento	404,200	354,700	467,100	408,500	507,200	472,600	406,900	283,300
Feather River								
Release Through Thermalito Diversion Dam	24,990	23,869	24,523	24,242	24,887	24,995	23,784	46,753
Thermalito Afterbay Release	34,299	123,538	33,747	57,726	98,618	71,590	45,991	8,944
Near Gridley	57,150	134,200	49,750	68,110	111,400	90,500	66,800	52,420
Below Shanghai Bend	67,500	131,100	62,000	75,750	116,200	95,250	72,260	66,890
At Nicolaus	72,330	124,900	64,640	71,750	110,700	94,630	76,270	68,880
American River								
At Fair Oaks	16,810	15,340	31,990	67,520	53,420	52,600	35,820	17,460
At Sacramento	17,880	13,830	30,380	62,910	50,460	48,490	32,070	16,120
Minor Streams Tributary to Sacramento River								
Spring Creek at Keswick	71,030	44,880	152,900	176,300	227,400	224,700	95,810	16,300
Clear Creek Near Igo	3,150	3,010	3,550	2,940	3,020	3,070	2,260	2,390
Cow Creek Near Millville	7,250	3,750	8,360	1,080	39	46	2,620	2,620
Battle Creek Below Coleman F.H.	16,360	13,750	16,360	13,300	12,330	11,760	12,320	12,590
Cottonwood Creek Near Cottonwood	8,970	8,100	10,150	4,430	3,051	2,880	5,380	5,772
Red Bank Creek Near Red Bluff	444	25	511	0	0	0	28	0
Fish Water Release, Coyote Creek	7,962	7,740	12,815	8,990	1,490	1,958	0	2,933
Antelope Creek Near Red Bluff	2,860	2,550	2,880	1,970	1,750	1,760	2,017	2,404
Mill Creek Near Los Molinos	6,560	6,630	7,530	7,890	4,400	4,110	5,090	5,030
Elder Creek Near Paskenta	1,460	824	823	150	19	0	69	71
Thomes Creek Near Paskenta	3,810	3,950	2,680	990	105	3	248	515
Deer Creek Near Vina	6,710	5,920	6,260	4,510	3,850	3,830	4,210	4,430
Stoney Creek Near Orland	0	3,790	986	2,210	1,880	1,150	701	279
Mud Creek Near Chico	85	29	148	0	26	47	47	0
Big Chico Creek at Chico	1,359	768	839	124	0	0	163	199
Streams Tributary to Feather River								
Kelley Ridge Power Plant	0	60	0	647	187	102	341	331
North Honcut Creek Near Bangor	205	93	529	408	569	566	168	744
South Honcut Creek Near Bangor	413	132	439	293	269	133	275	88
Jack Slough Near Marysville	118	534	5,012	1,539	2,275	5,651	5,508	2,911
Yuba River Near Marysville	11,530	10,290	10,220	9,210	5,430	4,410	5,110	15,950
Bear River Near Wheatland	66	35	249	189	181	290	78	0

Metric Conversion: Acre-feet times 1233.5 equals cubic metres.

TABLE 6 (Cont'd.)

MONTHLY FLOWS AT SURFACE WATER MEASUREMENT STATIONS - 1977

Station	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
				Acre-Feet				
Irrigation Return Flow to Sacramento River								
Butte Slough Outfall Gates	0	0	708	0	0	0	0	0
R.D. 70 Drain	637	595	801	378	97	190	470	202
R.D. 108 Drain	1,857	1,916	5,774	6,163	1,906	5,738	8,450	541
R.D. 787 Drain	501	225	1,068	1,022	645	1,499	671	195
Sycamore Slough (R.D. 787)	0	0	248	496	0	4	219	0
Colusa Basin Drain	7,200	589	29,750	83	149	18,540	27,990	778
Sacramento Slough	21,200	13,820	34,030	12,900	11,290	16,940	26,870	10,490
R.D. 1001 Drain	90	272	300	0	103	0	296	49
R.D. 1000 Drain No. 4	0	0	0	0	0	0	0	0
R.D. 1000 Drain No. 6	0	0	0	0	0	0	940	0
R.D. 1000 Drain No. 3	1,676	430	2,209	0	0	0	3,032	0
R.D. 1000 Drain (2nd Bannon Slough)	0	0	0	0	0	0	0	110
R.D. 1500 Drain	3,059	1,817	5,647	4,554	3,455	3,824	6,426	2,656
Natomas Cross Canal at Head	0	0	0	0	0	0	0	0
Natomas East Main Drain	2,142	603	2,251	228	213	270	937	359
Irrigation Return Flow to Feather River								
Cox Spillway	0	0	0	601	1,164	1,369	413	0
Exportation From Delta								
California Aqueduct	96,573	14,214	72,301	17,114	20,353	15,422	9,182	7,779
Delta Mendota Canal [1/]	124,713	59,318	101,835	18,117	20,674	67,358	97,581	29,267
Contra Costa Canal	7,672	7,121	6,736	10,834	8,902	8,664	7,289	8,336
City of Vallejo	1,013	1,118	1,256	1,488	1,577	1,071	706	875
East Bay Municipal Utility District [2/]							6,016	5,881
Total Exportation from Delta	229,971	81,771	182,128	47,553	51,506	92,515	120,774	52,138
Surface Inflow to Delta								
Sacramento River at Sacramento	404,200	354,700	467,100	408,500	507,200	472,600	406,900	283,300
Yolo Bypass Near Woodland	218	36	34	32	33	34	37	NA
S. F. Putah Creek Near Davis	0	0	0	0	0	0	0	0
Morrison Creek Near Sacramento	522	146	350	156	128	146	231	159
Cosumnes River at McConnell	37	0	62	0	0	0	0	0
Dry Creek Near Galt	0	0	0	0	0	0	0	0
Mokelumne River at Woodbridge	1,620	537	533	496	568	404	305	130
Bear Creek Near Lockford	4	2	3	15	22	24	15	10
Mosher Slough Near Stockton	304	243	298	187	353	231	210	0
Calaveras River Near Stockton	479	509	576	478	643	172	0	0
Stockton Diverting Canal at Stockton	87	64	174	49	92	58	0	0
Duck Creek Near Stockton	238	327	291	505	709	879	458	145
French Camp Slough Near French Camp	144	48	365	280	220	346	837	255
San Joaquin River at Vernalis	32,200	12,620	24,580	7,020	5,710	7,640	10,630	15,160
Marsh Creek Near Byron	0	0	0	0	0	0	0	0
Total Surface Inflow To Delta	440,053	369,232	494,366	417,718	515,678	482,534	419,623	299,159

1/ Delta Mendota Canal flows have been reduced by the amounts diverted to Banta Carbona Irrigation District and West Side Irrigation District as these Districts are within the Delta Service Area.

2/ Started operations September 1, 1977.

NA - Not Available.

Metric Conversion: Acre-feet times 1233.5 equals cubic metres.

TABLE 7

AVERAGE GROUND WATER LEVEL CHANGES BY COUNTY
SPRING 1975 - SPRING 1977

County	No. of Wells Measured	Average Change Feet 1/
Tehama	57	-9.4
Glenn	89	-12.6
Butte	48	-9.0
Colusa	56	-9.6
Yuba	84	-9.5
Sutter	129	-11.1
Placer	63	-6.9
Yolo 2/	153	-26.3
Sacramento 2/	54	-4.2

1/ 1 foot = 0.3048 metres.
2/ In area north of Sacramento.

TABLE 8

MONTHLY DIVERSIONS - 1977

SACRAMENTO RIVER

Location	Mile and Bank Above Sacramento	Monthly Diversions in Acre-Feet								Total Diversions in Acre-Feet
		Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
TOWER BRIDGE - SACRAMENTO	0.0									
GAGING STATION - SACRAMENTO	0.6L									
	0.8L	3,844	5,224	4,884	4,145	5,296	5,411	4,877	5,163	38,844
AMERICAN RIVER	1.1L									
BACK BORROW PIT - RECLAMATION DISTRICT 1000	1.3L									
RECLAMATION DISTRICT 1000 DRAIN (2nd Bannon Slough)	1/ 2.1L									
	1/ 2.15L	18	43	52	39	42	20	21		235
	3.55R	116	51	75	101	101	58	35		537
	4.0R									0
STAGE STATION - SACRAMENTO RIVER AT SACRAMENTO WEIR	4.0R									
	4.65R		55	4	13	14	7			93
	5.05R	46	73	19	31	45	42	29	15	300
	5.25R		109	10	60	55	29			263
	5.3R		66	9	38	42	13			168
	5.5R	1	7	8	12	13	12	8	2	63
	5.55R	267	1	52	40	110	64			534
	1/ 6.1L	760	1,400	1,243	1,700	1,591	1,106	431	49	8,280
RECLAMATION DISTRICT 1000 DRAIN NO. 3	6.85L									
	1/ 7.5L	73	70							143
	7.7R	81	153		143	158	129	29		693
	7.8L	112	120	194	34					460
	7.9L		28	198	156	153	66			601
	8.3R	95	234	55	132	91	154	20		781
	9.3L	215	89	93	116	103	100	22		738
	9.35R	283	265	154	268	273	261	44		1,548
	9.8L	4	14	20	28	33	37	19	2	157
	9.9R	66	178	13	189	163	103			712
	1/ 10.25L	246	80	61	233	169	130			919
	10.65R		141	69	69	111	133	34		557
	1/ 11.1R	169	145	60			124			498
INTERSTATE 5 BRIDGE	11.7									
ELKHORN FERRY (SITE)	11.9									
	1/ 12.0R		6,048	4,381	7,801	6,702	4,440		430	29,802
	12.5R	85	23	81						189
	12.7R	168	261	148						577
	12.95L									0
	13.1R									0
	13.25R		132	200	107	47	62			548
	1/ 14.1L	1,500	2,226	1,058	2,027	2,076	1,077	263	170	10,397
	14.25R	244	316	262	293	189	277	94	243	1,918

Metric Conversion: Acre-feet times 1233.5 equals cubic metres.
Miles times 1.6093 equals kilometres.

TABLE 8 (Cont'd)

MONTHLY DIVERSIONS - 1977

SACRAMENTO RIVER

Location	Mile and Bank Above Sacramento	Monthly Diversions in Acre-Feet								Total Diversions in Acre-Feet
		Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
	1/ 15.1R	164	66	37	36	16	22	23		364
	1/ 16.0L	2,077	4,523	3,702	6,522	6,281	5,010	721		28,836
	1/ 16.27R									0
	1/ 16.62R	71	152	31	82	102	123	38	9	608
	1/ 17.0R		47	45	59	80	71			302
	17.4R	298		182	73		238			791
	17.75		220	56	295	438	181			1,190
	18.0R		404	139	200	473	215			1,431
	18.2L	43	75	43	31	75	43	30		340
	18.45L	141	72	146	267	210	254	76		1,166
	18.7R		343	172	118	224	304			1,161
	18.7L	47	45	20	100	160	107	115		594
SACRAMENTO TO VERONA										
Reach Totals		11,234	23,499	17,976	25,558	25,636	20,423	6,929	6,083	137,338
GAGING STATION - SACRAMENTO RIVER AT VERONA	19.6L									
CROSS CANAL - RECLAMATION DISTRICTS 1000 AND 1001	19.6L									
	2/ (0.05S)		79	105	160	172	220	131		867
RECLAMATION DISTRICT 1001 DRAIN	(0.75N)									
	1/ (1.0S)	718	2,182	1,935	3,024	3,189	2,643	761		14,452
RECLAMATION DISTRICT 1000 DRAIN	(1.5S)									
	1/ (2.0S)	2,343	3,289	4,409	4,055	5,616	5,324	2,752		27,788
	1/ 2/ (3.3N)		693	99	439	668	407	72		2,378
	1/ 2/ (3.35N)									3/
	1/ 2/ (3.45N)	174	779	56						1,009
EL CENTRO ROAD BRIDGE	2/ (4.1)									
FEATHER RIVER	20.9L									
SACRAMENTO SLOUGH	21.2L									
	21.75R	141	237	25	226	76	204		16	925
	1/ 22.5R	458	357	65	46	159	80	68		1,233
STAGE STATION - SACRAMENTO RIVER AT FREMONT WEIR - EAST END	22.58R									
	22.6L			354	12	35		40		441
STAGE STATION - SACRAMENTO RIVER AT FREMONT WEIR - WEST END	27.9R									
	1/ 28.1R		22	120	333	106				581
	1/ 28.2L	173								173
	28.6L			108		32	64			204

Metric Conversion: Acre-feet times 1233.5 equals cubic metres.

Miles times 1.6093 equals kilometres.

TABLE 8 (Cont'd)

MONTHLY DIVERSIONS - 1977

SACRAMENTO RIVER

Location	Mile and Bank Above Sacramento	Monthly Diversions in Acre-Feet								Diversions in Acre-Feet
		Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
	28.6R	14	6	10	26	20	16	34		126
	29.1R									0
	29.5R									0
	1/ 29.7R	99	145		70	44	10			368
	29.8L			489	301	172	42			1,004
	30.2L									0
	30.3R									0
	30.4R				231		99	29		359
	1/ 30.5L	5/	72		19	89	26			206
	1/ 30.7R	4/	24							24
	30.9L			52	13	17				82
	31.8R									0
	1/ 32.1R	4/	306	180	308	188	2			984
	1/ 32.4L	460	2,081	2,674	3,074	3,464	2,989	235	48	15,025
	32.5L		68		6	34				108
	32.6R				72	127	95		29	323
	33.0L	673		451	790	782				2,696
	33.0L			531	307	295	211			1,344
	33.2L	27	240	143	284	175				869
	33.5R		13	305	202	162	67	7		756
	1/ 33.7L	87	112	42	163	101				505
VERONA TO KNIGHTS LANDING Reach Totals		5,367	10,705	12,153	14,161	15,723	12,499	4,129	93	74,830
GAGING STATION - SACRAMENTO RIVER AT KNIGHTS LANDING	34.0L									
KNIGHTS LANDING BRIDGE	34.1									
COLUSA BASIN DRAIN	34.15R									
	1/ 34.5R	1,143	273		473	33	154		1,288	3,364
	34.8L	113	268			254	2			637
	1/ 35.2L	359	20		41	85				505
	35.7L	20	58	32	84	44				238
	35.8L	13	32	8	16	24	24			117
	36.2L	38	441	328	707	629	372			2,515
	36.4L	95	54		58	64	115	72		458
RECLAMATION DISTRICT 787 DRAINAGE PLANT	37.0R									
	37.5L	37	18		18	18	17			108
	37.8L	556	231	286	285	266	438	234	21	2,317
	37.9L		14	19	74	69	14			190
	38.5L	141	61							202

Metric Conversion: Acre-feet times 1233.5 equals cubic metres.
Miles times 1.6093 equals kilometres.

TABLE 8 (Cont'd)

MONTHLY DIVERSIONS - 1977

SACRAMENTO RIVER

Location	Mile and Bank Above Sacramento	Monthly Diversions in Acre-Feet								Total Diversions in Acre-Feet
		Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
	38.8L	55	55	5						115
	39.4L	118	85							203
	39.8L	112	129							241
	39.9L			3	3					6
	1/ 40.6L	622	2,818	3,628	3,735	3,306	3,138	1,208		18,455
	1/ 41.0R	6/	269		736					1,005
	42.2L	41	75	56	69	61	23			325
	42.3R	508	761	723	1,255	1,251	394	564		5,456
	42.3L		114	85	35	35				269
	1/ 43.1R	6/	1,823	3,193	4,376	3,937	3,862	572		17,763
	1/ 43.1R	4,657	3,592		3,681	120	138			12,188
	1/ 43.4R	7/	171	36	201	172	80	75		735
	43.4L	284	221							505
RECLAMATION DISTRICT 108 DRAINAGE PLANT	44.0R									
	1/ 44.2L	336	208	30	124	38	1			737
	1/ 45.6L	9/	106	283			86	139	4	618
	1/ 46.4L	9/		248		184				432
	1/ 46.5L	243	263	17	71	91				685
	46.9L			110	30	77	84			301
	1/ 48.7L		423	893	802	753	164	24		3,059
	1/ 49.0L	344	99							443
	1/ 49.7L	10/	127	72	37	87				323
	50.8R									0
	1/ 51.1R	7/	2,420	2,838	3,516	3,415	3,174	1,135	23	16,521
	1/ 51.2L	46	140	366	216	206	118	96		1,188
	14/ 51.6R			39	65	52	52	13	13	234
	52.0L		656	239	219	233	42	77		1,466
	52.3L		151	53	32	44	55	40		375
	52.9L		241	46	2	46				335
	1/ 53.8R	7/	911	1,311	1,341	1,045	788	655	218	6,269
	53.9L		390	99						489
	1/ 55.1L	7/	281	182	234	71				768
	1/ 56.4R	7/	2,395	2,299	2,514	2,472	2,638	364	402	13,084
	1/ 56.9L	1,000	876	868	946	743	522	5		4,960
	1/ 57.2L									0
	57.5L	128	259	144	272	50				853
	1/ 58.3L	8/	175				149			324
	58.9L									0
	1/ 59.1R	7/	286	85	120	80	269	260	3	1,103
	59.9L	245	408	180	430	73				1,336

Metric Conversion: Acre-feet times 1233.5 equals cubic metres.

Miles times 1.6093 equals kilometres.

TABLE 8 (Cont'd)

MONTHLY DIVERSIONS - 1977

SACRAMENTO RIVER

Location	Mile and Bank Above Sacramento	Monthly Diversions in Acre-Feet								Total Diversions in Acre-Feet
		Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
	[1]60.4L	52	323	397	634	597	43			2,046
	60.5L	247	60	235	259	488		489		1,778
	[1]61.2R	[7]	88	27	80	76	44	27		342
	61.8L	156	99							255
	[1]62.3R	[7]	206	113	188	233	137	31	4	912
	62.3L	215	170	114	138	135	66			838
	[1]62.6R	[7]	28		34	46	8	29		145
	62.6R	13	198	11	277	285	30	195		1,009
KNIGHTS LANDING TO WILKINS SLOUGH										
Reach Totals		11,937	23,570	19,701	28,428	21,988	17,241	6,304	1,976	131,145
GAGING STATION - SACRAMENTO RIVER AT WILKINS SLOUGH	62.9R									
	[1]63.2R	3,652	20,047	11,019	20,704	19,054	16,227	6,239		96,942
	63.3L	36	151	109	81	81	130	85		673
	63.7L		174	631	634	677	596	305		3,017
	[1]63.7L	12,659	27,405	22,351	33,618	32,382	23,964	8,872		161,251
	[1]63.9L	228	176	281	397	268	137	31	242	1,760
TISDALE WEIR RECORDER STATION	64.2L									
	64.3R	111	268	330	326	206	98	65		1,404
	[1]64.4L		34	14	240	438	293			1,019
	64.4R		8							8
	64.5L	5	51	55	631	943	757			2,442
	65.7L	161	156	26		145	154	105		747
	65.6R		148	379	473	356	248			1,604
	66.4R	1,000	2,049	869	1,624	1,531	936	281		8,290
	[1]67.1L	540	906	514	731	1,011	846	83		4,631
	[1]67.1L									0
	[1]67.5L	620	1,048	621	1,376	326	217			4,208
RECLAMATION DISTRICT 70 DRAIN PLANT	68.8L									
	69.0R				1,272			324	199	1,795
	69.2R	79	628	570	548	627	329	457		3,238
	69.2R	295	614	687	726	934	696	409	267	4,628
	70.0R		123	100	59	88		43		413
	70.4L	83	62	18	18	29				210
	[1]70.4R	386	387							773
	[1]71.1L	1,591	776	875	938	1,189	581	137		6,087
	71.9R	107	317	87	153	70	63	33	44	874
	[1]72.1L	329	189	3	84	194	163	103	59	1,124
	[1]74.8L	[11]	135	426	609	743	559	293		2,765
	75.3R	5	129	60	115	78	125			512

Metric Conversion: Acre-feet times 1233.5 equals cubic metres.

Miles times 1.6093 equals kilometres.

TABLE 8 (Cont'd)

MONTHLY DIVERSIONS - 1977

SACRAMENTO RIVER

Location	Mile and Bank Above Sacramento	Monthly Diversions in Acre-Feet								Total Diversions in Acre-Feet
		Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
	75.9L	14	13	27	1	1				56
	1/ 76.1L	11/								0
	76.5R	176	172	154						502
	1/ 77.8R	1,280	412	182	206	381	160			2,621
	77.9L	232	507	118	175	234	164		148	1,578
	1/ 78.1R	12/	1,703	789	1,336	1,594	1,598	631	89	7,740
	1/ 78.7R	12/	595	430	511	637	565	88		2,826
	1/ 78.8R	12/	1,889	2,026	1,790	1,830	1,716	944		10,195
	78.9R	81	226	116	41	19				483
	79.0L	8	31	36	23	37	28			163
	79.3R				82	59				141
	79.5L	7	19	9	42	30				107
	79.7L	20	52	16	2	32				122
	1/ 80.0L	11/	2,278	2,102	2,664	2,677	2,327	1,294	396	13,738
	80.3R			116	90					206
	1/ 81.5L	266	117	70	150	145			426	1,174
	1/ 81.8L	13/	108	26		25	26			185
	82.5L	33	179	5	8	8	14			247
	83.0R	1,280	1,200	265	505	558	387	771	360	5,326
	83.2R	358	575	364	317	192	39	18	4	1,867
	83.3L	18	76		43	62	85	43		327
BUTTE SLOUGH OUTFALL GATES	84.0L									
	1/ 85.3L									0
	85.6R	203	138	130						471
	85.8L	23	104	342	522	367	382	397		2,137
	86.1R	229	220	184	230	139	135			1,137
	86.1L	113		114	135	111				473
	86.2R	39	42	11	22	12				126
	86.9R	76	12	85	107	85		33	32	430
	87.5L	13	12	11	12	15	15	17		95
	87.6L	20	2	9	10	14	9	9	2	75
	1/ 87.7R	42		73	33	81				229
	88.0R		15		14	14				43
	88.0L	10	2	49	26	47	14	37	28	213
	88.2R			11		10	10			31
	88.4L	27	3	72	72	49	70	149		442
	88.7L	56	11	92	92	97	65			413
	89.0L			354	354	187	82	125		1,102
	1/ 89.2R	254	53	174	185	282	109	63		1,120
	1/ 89.2L	7	64	523	486	514	477	14		2,085
	89.3L	303	567	507	507	272	527			2,683

Metric Conversion: Acre-feet times 1233.5 equals cubic metres.

Miles times 1.6093 equals kilometres.

TABLE 8 (Cont'd)

MONTHLY DIVERSIONS - 1977

SACRAMENTO RIVER

Location	Mile and Bank Above Sacramento	Monthly Diversions in Acre-Feet								Total Diversions in Acre-Feet
		Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
WILKINS SLOUGH TO COLUSA										
Reach Totals		27,075	67,378	49,617	76,150	72,187	56,123	22,498	2,296	373,324
GAGING STATION - SACRAMENTO RIVER AT COLUSA BRIDGE	89.4R									
	89.7L				163	88	49	115		415
	1/ 90.7R	349	328	642	530	456	490	162		2,957
	91.0R		94	43	71	61	51		52	372
	91.0L	5	6	7			8	9	3	38
COLUSA WEIR RECORDER STATION	92.4L									
	1/ 93.1R	9	21	31	24	16	3			104
	94.3R	451	695	751	47	73	910	167		3,094
	1/ 95.2L	94	271	242	367	435	131	95	188	1,823
	1/ 95.6L	98	430	685	711	796	494	152	300	3,666
	1/ 95.7L		98	209	278	276	266	26		1,153
	1/ 95.8L	30	155	32		44	63			324
	95.8R		30	77	39	85	47		90	368
	97.2R	30	25	77			46	23		201
	97.7R	9	9	12	15	27	35	16		123
	97.8R	169	163	760	441	311	359	212	20	2,435
	98.0L	41	68	19	64					192
	98.3R				5	12				17
	1/ 98.6L	138	220	200	257	194	102	5	55	1,171
	1/ 98.6L		238	216	341	257	135	7	73	1,267
	98.7R	17		35	22	43	38			155
	98.8L	3	4	85	5	157	159	168	5	586
	99.0R	37	41	52	32	45	39	3	2	251
	99.1L	32	30	206	28	90	37	33	47	503
	1/ 99.2L	68	107	600	771	858	747	40	520	3,711
	99.3R	107	220	339	77	251	507	366	246	2,113
	1/ 99.8L	277	86	403	416	472	351	27	14	2,046
	100.8L	133	5		68	39	44	42	22	353
	101.6L	8	13	26	7	20	18			92
	1/ 101.8L	101	181	95	142	65				584
	102.5R			3	6	6	7	6		28
	102.6L	79		28	20	29	20	22	3	201
	102.8R	628	382	1,078	955	1,146	1,046	503	296	6,034
	1/ 102.9L		225	74	117	193	192	77		878
STAGE STATION - SACRAMENTO RIVER AT MOULTON WEIR	103.6R									
	103.7R	274	538	702	336	554	184			2,588
	103.7R	242	683	1,066	574	377	307			3,249

Metric Conversion: Acre-feet times 1233.5 equals cubic metres.

Miles times 1.6093 equals kilometres.

TABLE 8 (Cont'd)

MONTHLY DIVERSIONS - 1977

SACRAMENTO RIVER

Location	Mile and Bank Above Sacramento	Monthly Diversions in Acre-Feet								Total Diversions in Acre-Feet
		Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
	[1]/103.8R		899	1,452	1,355	1,352	4			5,062
	104.1R	403	1,027	897	1,156	1,210	830			5,523
	[1]/104.8L	27	59	98	48	65	15		14	326
	[1]/106.0R	138	118	117	141	240		43		797
	106.5R	272	614	417	178	361		311		2,153
	106.5R	280	358	391	464	426	478	152		2,549
	110.0R	95	126	82	120	117		77		617
	110.1L	21		784	801	768				2,374
	[14]/110.7L		12	19	31	25	25	6	6	124
	112.0L	18		18		18		20		74
	[1]/112.1L	2,520	7,258	10,190	10,188	10,050	6,603	725	4,156	51,690
	112.3L	46	54	96	61	82		76	10	425
	[1]/112.4R	1,294	4,102	1,460	2,295	1,803	1,325	440		12,719
	[14]/113.3L		26	40	66	53	53	13	13	264
	114.1R									0
	114.2R									0
	114.3R	115	151		217	77		68		628
	114.9R	51	124	6	44	68	93	37		423
	115.0R	88	401	535	220	705	44	223	96	2,312
	115.5R		19	16	18	11	13			77
COLUSA TO BUTTE CITY										
Reach Totals		8,797	20,714	25,413	24,332	24,907	16,368	4,467	6,231	131,229
GAGING STATION - SACRAMENTO RIVER AT BUTTE CITY	115.8L									
	117.1R									0
	117.2R									0
	123.6R	31	40	4	31	27	20			153
	[1]/123.9R	2,270	7,198	5,430	7,520	7,041	5,847	1,864		37,170
	[1]/124.2R	1,558	10,442	3,282	8,056	6,119	5,017	1,077	1,095	36,646
	125.6R	11	18	13	2	5				49
	128.3R		82	199	40	60	109	99	29	618
	129.2L	102	97	887	1,419	1,801	1,755	784		6,845
	130.8R	27	60	38	149	204	221	83		782
BUTTE CITY TO ORD FERRY										
Reach Totals		3,999	17,937	9,853	17,217	15,257	12,969	3,907	1,124	82,263
GAGING STATION - SACRAMENTO RIVER AT ORD FERRY	130.8R									
	132.8L		401	277	52	59	40			829
	133.4L			234	77	210	65	17		603
	133.5L		8	10	2					20

Metric Conversion: Acre-feet times 1233.5 equals cubic metres.
Miles times 1.6093 equals kilometres.

Table 8 (Cont'd)

MONTHLY DIVERSIONS - 1977

SACRAMENTO RIVER

Location	Mile and Bank Above Sacramento	Monthly Diversions in Acre-Feet								Total Diversions in Acre-Feet
		Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
	[14] 134.8R		19	28	47	37	37	9	9	186
	135.5R		3	4	15	15	9		5	51
	[1] 141.5L	341	699	1,947	2,840	3,346	3,228	535		12,936
	142.8R	165	189	121	33	92	3			603
	143.6R	167	291	176	14					648
ORD FERRY TO HAMILTON CITY										
Reach Totals		673	1,610	2,797	3,080	3,759	3,382	561	14	15,876
GAGING STATION - SACRAMENTO RIVER AT HAMILTON CITY	149.5L									
	150.8R	88	75			250	428	158		999
	151.2L	256	447	221	878	1,127	993	376		4,298
	153.6L	362	717	1,059	332	758	763	101		4,092
	154.0L							15		15
	[1] 154.8R	47,047	107,537	79,168	109,784	114,655	97,437	28,870	21,966	606,464
	155.6R	8	20	6	17	26	23	11	17	128
	156.6R	7	15	4	4	4	4	2	2	42
	156.7R	4	4	2	6	9	5	3	2	35
	156.8R	13	48	13	47	60	56	37	26	300
	161.7L		130	81	190	228	228	17		874
	161.8L	17	36	19	43	45		112		272
	165.0L	34	33	81	57	82	100	12		399
	166.2L	16	17							33
HAMILTON CITY TO VINA BRIDGE										
Reach Totals		47,852	109,079	80,654	111,358	117,244	100,037	29,714	22,013	617,951
GAGING STATION - SACRAMENTO RIVER AT VINA BRIDGE	166.5R									
	168.7R	3	32	1	3					39
	169.8L		9							9
	170.0R	87	38	43	52	143	151	15		529
	170.9L									0
	171.9R	14	14	12	14	34	30	13	50	181
	172.8L		48	159	189	137	137	77		747
	[14] 173.3L		12	19	31	25	25	6	6	124
	173.6L		10	8	10	5	5	5	6	49
	174.9R				83	42	42	42	81	290
	176.9R	11	11	6						28
	179.6R									0
ANTELOPE CREEK	180.3L									
	182.1L		7		7	7	4		4	29
	182.3L	7	4	4	11		11			37

Metric Conversion: Acre-feet times 1233.5 equals cubic metres.

Miles times 1.6093 equals kilometres.

TABLE 8 (Cont'd)

MONTHLY DIVERSIONS - 1977

SACRAMENTO RIVER

Location	Mile and Bank Above Sacramento	Monthly Diversions in Acre-Feet								Total Diversions in Acre-Feet
		Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
	187.5L			2	2	3	1	2		10
	188.0L		1	16	17	15		40	8	97
	189.1R									0
	[14]/ 190.2L	9	45	75	53	63	42	11		298
	[15]/ [1]/ 191.2R	157	2,340	1,002	2,453	3,041	3,213	2,690	2,013	16,909
	[16]/ [1]/ 191.2R	8,488	13,827	16,037	38,424	28,920	8,567	3,265	5,110	122,638
	[1]/ 191.5R	11	24	14		35	35	25	24	168
RED BLUFF BRIDGE	193.45									
	196.5L						2	1		3
	196.6L		17	15		38	26	19	19	134
	201.6L				10	44	26	14		94
	205.2L	9	22	13	25	12	2	1		84
BEND BRIDGE	207.0									
	207.3L									0
	207.5L		5	5	33	43		70	4	160
VINA BRIDGE TO ABOVE BEND BRIDGE										
Reach Totals		8,796	16,466	17,431	41,417	32,607	12,319	6,296	7,325	142,657
GAGING STATION - SACRAMENTO RIVER ABOVE BEND BRIDGE	209.7									
	213.0R									0
	213.5L		29	14	48	52	63	13		219
	215.0L									0
	216.0R		22		37	38	23	23		143
	[14]/ 216.7L		9	14	23	18	18	5	5	92
	217.9L									0
	[1]/ 221.0R		45	75	113	128	105	82	37	585
COTTONWOOD CREEK	222.2R									
	223.8L				17	56	48		5	126
	[14]/ 225.6R		65	97	161	129	129	32	32	645
	225.9L	7	4	5	3	6	6	6	7	44
	228.0R			1	2	1	1			5
	229.0L					21	28	15		64
	229.4L		26			39	32	22		119
	233.5L									0
	233.8R	21	21	33	36	40	27	34	31	243
	234.0L	4	16	4	33	36	29	7		129
	235.0R				960	1,463				2,423
CLEAR CREEK	237.1R									
	238.9L	24	65	17	69	87	105	103	21	491
	240.2L			16	34	50	43	30	6	179

Metric Conversion: Acre-feet times 1233.5 equals cubic metres.

Miles times 1.6093 equals kilometres.

TABLE 8 (Cont'd)

MONTHLY DIVERSIONS - 1977

SACRAMENTO RIVER

Location	Mile and Bank Above Sacramento	Monthly Diversions in Acre-Feet								Total Diversions in Acre-Feet
		Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
	1/ 240.5L		2,397	954	3,202	3,600	3,419	1,678	784	16,034
	240.8L	5	4	22	26	47	37	37	7	185
	1/ 244.4L	135	592	242	1,303	2,021	1,873	871	273	7,310
	17/ 1/ 246.0R	1,525	19,422	6,388	21,988	22,132	20,304	13,482	11,605	116,846
	1/ 246.3R	5	16	5	34	29	27	17	9	142
	1/ 246.7R	363	444	348	814	869	860	581	396	4,675
GAGING STATION - SACRAMENTO RIVER AT KESWICK	250.5									
BEND BRIDGE TO KESWICK										
Reach Totals		2,089	23,177	8,235	28,903	30,862	27,177	17,038	13,218	150,699
TOTAL DIVERSION										
Sacramento to Keswick		127,819	314,135	243,830	370,604	360,170	278,538	101,843	60,373	1,857,312

1/ Record furnished by U. S. Bureau of Reclamation (USBR).
2/ Items in parenthesis are located on Cross Canal, on north or south bank as shown.
3/ Included in diversion listed for (3.3N).
4/ Included in diversion listed for 29.7R.
5/ Included in diversion listed for 28.2L.
6/ Included in diversion listed for 34.5R.
7/ Included in diversion listed for 43.1R.
8/ Included in diversion listed for 35.2L.
9/ Included in diversion listed for 44.2L.
10/ Included in diversion listed for 49.0L.
11/ Included in diversion listed for 71.1L.
12/ Included in diversion listed for 77.8R.
13/ Included in diversion listed for 81.5L.
14/ No records on diesel installations, last year's figures are used.
15/ Pumped diversion: Corning Canal.
16/ Gravity diversion: Tehama-Colusa Canal and spawning channel.
17/ Gravity diversion: Anderson-Cottonwood Irrigation District.

Metric Conversion: Acre-feet times 1233.5 equals cubic metres.

Miles times 1.6093 equals kilometres.

TABLE 9

MONTHLY DIVERSIONS - 1977

FEATHER RIVER

Location	Mile and Bank Above Mouth	Monthly Diversions in Acre-Feet								Total Diversions in Acre-Feet
		Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
MOUTH OF FEATHER RIVER	0.0									
	0.6R			695	23	415	22	3		1,158
	1.0R	161		527	55	79	10	20		852
	1.1L	138	164	143	134	144	157	95		975
	1.5R					27		123		150
	2.2L	70	61	82	119	112	52			496
	2.6R	165		1,637	62	584	75	1		2,524
	2.6L	77	85	86	121	143	71			583
	4.0R			640	461	296	19			1,416
	4.55L	57	170	290	272	320	260	93	8	1,470
	4.9R									0
	5.2L	83	99	48	5		15	21	6	277
	5.6L	150	284	354	421	597	456	146		2,408
	6.44L			24	50	90	90	41	11	306
	7.2L	184	130	52		171	183			720
MOUTH TO NICOLAUS										
Reach Totals		1,085	993	4,578	1,723	2,978	1,410	543	25	13,335
GAGING STATION - FEATHER RIVER AT NICOLAUS	8.0L									
HIGHWAY 99 BRIDGE (NICOLAUS BRIDGE)	9.2L									
	9.25L	22	35	34	38	35	35	13		212
	9.75R 1/		502	1,778	1,878	2,297	1,777	1,552	208	9,992
	11.3R	7	30	26	29	36	27	11		166
	12.0L									0
	13.1R 1/	971	1,120	2,150	2,717	2,946	1,945	174	594	12,617
	15.2R	29	34	39	48	60	56	27	2	295
	15.2R 1/	112	1,586	712	139	900	396	53	29	3,927
	17.5L 1/	588	1,639	650	1,527	2,249	985	929	236	8,803
	17.9L		7	9	8	15	21	20	8	88
	18.4R 1/	434	709	530	554	668	113	113	18	3,139
	18.4R	58	47	5	119	153	36	13	18	449
	18.6L									0
	19.0R									0
	19.1R	52	114	119	157	173	51			666
	19.3R	54	38							92
	19.8R									0
	20.0R									0
	20.4R		11	11	9	5				36
	20.4R 1/	319	811	349	1,020	262	182	218	1	3,162
	20.9L									0
	21.4R 1/	145	254	21	227	237	109	149	41	1,183
	21.9L						13	33	23	69
NICOLAUS TO SHANGHAI BEND										
Reach Totals		2,791	6,937	6,433	8,470	10,036	5,746	3,305	1,178	44,896

1/ Measured each year by the Department.

Metric Conversion: Acre-feet times 1233.5 equals cubic metres.

Miles times 1.6093 equals kilometres.

TABLE 9 (Cont'd)

MONTHLY DIVERSIONS - 1977

FEATHER RIVER

Location	Mile and Bank Above Mouth	Monthly Diversions in Acre-Feet								Total Diversions in Acre-Feet
		Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
GAGING STATION - FEATHER RIVER BELOW SHANGHAI BEND	23.0R									
	26.8L									0
	27.0L	159	218	134	225	239	206	101	292	1,574
YUBA RIVER	27.3L									
GAGING STATION - FEATHER RIVER AT YUBA CITY	28.0									
STATE HIGHWAY 20 BRIDGE	28.2									
	29.6R 1/	201	427	286	589	585	619	475	304	3,486
	30.9R	41	30	19	44	35	5	21	22	217
	31.6R									0
	32.1L	7	30	13	45	27	24	12	19	177
	32.3R	28	51	33	75	76	44			307
	33.0R		4	44	36	11		38	26	159
	33.3R	111	89	65	72	102	55		4	498
	33.9R	83	88	56	94	79	37	24		461
	35.0L		15		34	28	9		20	106
	37.0R		1	7	4	8	5			25
	37.5L	12	12	9	15	13	9			70
	38.1R 1/		8,079	9,919	5,463	5,144	724	184		29,513
	38.5L	43	48	38	38	50	48	1		266
	38.53L				6	65	61	24	149	305
	39.4L	21	19	21	18	18	10	15		122
	41.15R	33	29	26	42	24	6	3	2	165
	41.5R	23	19	17	27	22	11	6	3	128
	42.1L	121	166	70	161	166	155	6		845
	43.3L									0
	43.5L	28	59	52	42	62	67	36	43	389
HONCUT CREEK	43.7L									
Honcut Creek Diversion	(0.4L) 2/	589	449	304	597	560	246	333		3,078
	46.0	21	36	33	38	102	187	96		513
	47.9L	155	150	200	230	419	294	245	129	1,822
	48.0L	89	142	150	160	147	147	98	49	982
	48.3L				- NO DIVERSIONS -					
	48.9R		8	8	9	7	11	2		45
	49.0L	12	31	29	34	50	29	10	1	196
GRIDLEY BRIDGE	49.6									
SHANGHAI BEND TO GRIDLEY										
Reach Totals		1,777	10,200	11,533	8,098	8,039	3,009	1,730	1,063	45,449
GAGING STATION - FEATHER RIVER NEAR GRIDLEY	49.7R									
	49.7L	12	2	5	5	9	6			39
	50.4L	67	141	129	110	144	170	63	4	828
	50.7L	9	23	8	10	20	14			84

1/ Measured each year by the Department.

2/ Distance in parentheses is from mouth of Honcut Creek.

Metric Conversion: Acre-feet times 1233.5 equals cubic metres.
Miles times 1.6093 equals kilometres.

TABLE 9 (Cont'd)

MONTHLY DIVERSIONS - 1977

FEATHER RIVER

Location	Mile and Bank Above Mouth	Monthly Diversions in Acre-Feet								Total Diversions in Acre-Feet
		Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
	52.1L	42	148	197	132	151	54	15	6	745
	52.5L	31	49	19	53	67	69			288
	52.7L	2	7	19	22	19	17	14	6	106
	53.31L	1	3	6	6	9	7	5	2	39
	53.32L	1	5	10	13	14	14	10	4	71
GRIDLEY TO THERMALITO AFTERBAY RIVER OUTLET										
Reach Totals		165	378	393	351	433	351	107	22	2,200
THERMALITO AFTERBAY RIVER OUTLET	58.2R									
Western Canal	19/3-18D* 1/		33,654	29,397	42,590	45,101	32,843	2,971	7,690	194,246
Richvale Canal	19/3-18D* 1/		4,788	9,951	13,629	16,528	12,393	502		57,791
PG&E Laterial	19/3-19E* 1/		875	505	802	886	637	5	6	3,716
Sutter Butte Canal	18/3-5B* 1/	26,871	20,520	31,522	50,390	56,683	48,719	16,864	4,723	256,292
THERMALITO DIVERSION DAM	65.6									
ORDVILLE DAM	70.4									
THERMALITO AFTERBAY RIVER OUTLET TO OROVILLE DAM										
Reach Totals		26,871	59,837	71,375	107,411	119,198	94,592	20,342	12,419	512,045
TOTAL DIVERSIONS										
Oroville Dam to Mouth		32,689	78,345	94,312	126,053	140,684	105,108	26,027	14,707	617,925

*Diversions are from Thermalito Afterbay. Figures represent North Townships, East Ranges, and Sections. Letters represent the 1/4-1/4 sections which are lettered from A through R, excluding I and O, similar to the numbering of sections within a township

1/ Measured each year by the Department.

Metric Conversion: Acre-feet times 1233.5 equals cubic metres.
Miles times 1.6093 equals kilometres.

TABLE 10

MONTHLY DIVERSIONS - 1977

YUBA RIVER 1/

Mouth to Gaging Station - Yuba River near Marysville

Location	Mile and Bank Above Mouth	Monthly Diversions in Acre-Feet								Total Diveraions in Acre-Feet
		Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
HIGHWAY BRIDGE AT MOUTH	0.0									
	0.9L	144	191	81	135	99	1	12	10	673
SIMPSON LANE BRIDGE	0.9									
	1.5R	1	4	6	10	10	5	3	2	41
	1.7R									0
	3.0L	149	82	87	186	218	182			904
	3.05R	2	25	23	61	75	53	9		248
	4.1L	91	194	205	198	198	153	86	107	1,232
	4.4L	20	37	34	41	39	23	10	4	208
	4.75L	24	34	30	63	50	27	7		235
GAGING STATION - YUBA RIVER NEAR MARYSVILLE	5.15L	18	38	32	33	45	30			196
MOUTH TO GAGING STATION NEAR MARYSVILLE										
Reach Totals		449	605	498	727	734	474	127	123	3,737

1/ Diversions below the gaging station have been recorded to determine the net tributary inflow to the Feather River from this source. These diversions are included in Table 14 as noted with the diversions from Shanghai Bend to Gridley.

Metric Conversion: Acre-feet times 1233.5 equals cubic metres.
Miles times 1.6093 equals kilometres.

TABLE 11

UNIT CONSUMPTIVE USE OF WATER - 1977

DELTA SERVICE AREA

Classification	Acre-Feet Per Acre								
	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Total
AGRICULTURAL									
Irrigated (Single Crop)									
Grain	0.36	0.48	0.26	0.15	0.08	0.08	0.13	0.13	1.67
Rice	0.16	0.23	0.47	0.73	0.82	0.67	0.46	0.28	3.82
Safflower	0.16	0.21	0.40	0.72	0.64	0.37	0.21	0.16	2.87
Sugar Beets	0.16	0.18	0.31	0.63	0.67	0.53	0.37	0.20	3.05
Field Corn	0.16	0.18	0.19	0.48	0.58	0.42	0.22	0.16	2.39
Milo (Grain Sorghum)	0.16	0.18	0.17	0.49	0.61	0.36	0.21	0.16	2.34
Sudan	0.36	0.48	0.40	0.58	0.64	0.41	0.39	0.20	3.46
Dry Beans	0.16	0.18	0.14	0.48	0.52	0.22	0.21	0.16	2.07
Miscellaneous Field	0.16	0.18	0.20	0.51	0.62	0.42	0.16	0.16	2.41
Alfalfa	0.27	0.41	0.37	0.54	0.62	0.54	0.41	0.28	3.44
Pasture	0.30	0.45	0.40	0.58	0.64	0.53	0.39	0.28	3.57
Asparagus	0.16	0.18	0.08	0.29	0.64	0.53	0.39	0.20	2.47
Potatoes	0.16	0.18	0.14	0.36	0.62	0.46	0.23	0.16	2.31
Tomatoes	0.16	0.18	0.22	0.33	0.68	0.50	0.19	0.16	2.42
Miscellaneous Truck	0.16	0.27	0.38	0.56	0.62	0.43	0.31	0.16	2.89
Fruit and Nuts	0.22	0.32	0.33	0.51	0.62	0.51	0.36	0.22	3.09
Vineyards	0.16	0.18	0.23	0.44	0.54	0.44	0.28	0.20	2.47
Fallow	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.64
Irrigated (Double Crop) 1/									
Sugar Beets	0.36	0.48	0.26	0.15	0.36	0.43	0.48	0.28	2.80
Field Corn	0.36	0.48	0.26	0.15	0.36	0.52	0.51	0.22	2.86
Milo (Grain Sorghum)	0.36	0.47	0.26	0.15	0.22	0.51	0.43	0.16	2.57
Sudan	0.36	0.48	0.26	0.30	0.64	0.41	0.39	0.16	3.00
Dry Beans	0.36	0.48	0.26	0.26	0.62	0.29	0.12	0.16	2.55
Tomatoes	0.36	0.48	0.26	0.19	0.55	0.50	0.43	0.16	2.93
Potatoes				NO DOUBLE CROP POTATOES					
Lettuce	0.36	0.48	0.26	0.34	0.62	0.44	0.41	0.20	3.11
Miscellaneous Truck	0.36	0.48	0.26	0.19	0.55	0.50	0.43	0.16	2.93
Miscellaneous Field	0.36	0.48	0.26	0.34	0.62	0.44	0.41	0.28	3.19
Non-Irrigated									
Fruit and Nuts	0.31	0.32	0.17	0.19	0.22	0.19	0.17	0.13	1.70
Vineyard	0.31	0.32	0.17	0.19	0.22	0.19	0.17	0.13	1.70
Grain	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.64
Fallow	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.64
NONAGRICULTURAL									
Native Vegetation	0.31	0.32	0.17	0.19	0.22	0.19	0.17	0.13	1.70
Riparian Vegetation	0.38	0.62	0.55	0.81	0.98	0.81	0.58	0.36	5.09
Water Surface	0.38	0.62	0.55	0.81	0.98	0.81	0.58	0.36	5.09
Urban	0.08	0.16	0.20	0.20	0.21	0.20	0.16	0.13	1.34

1/ Double cropped with grain.

Metric Conversion: Acre-Feet per acre times 0.3048 equals cubic metres per square metre.

TABLE 12

CONSUMPTIVE USE OF WATER - 1977

DELTA SERVICE AREA[1/]

Classification	Area In Acres	Thousands of Acre-Feet								
		Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Total
AGRICULTURAL										
Irrigated (Single Crop)										
Grain[2/]	93,020	33.3	44.2	24.1	14.0	7.8	7.8	12.4	12.4	156.0
Rice	480	0	0.2	0.2	0.4	0.4	0.4	0.2	0.2	2.0
Safflower	29,270	4.6	6.1	11.7	21.2	18.8	10.7	6.1	4.6	83.8
Sugar Beets	30,760	4.9	5.6	9.4	19.4	21.3	16.4	11.3	6.2	94.5
Field Corn	123,300	19.5	22.6	23.7	58.5	70.9	52.4	26.7	19.5	293.8
Milo (Grain Sorghum)	5,230	0.8	1.0	0.9	2.6	3.2	1.9	1.1	0.8	12.3
Sudan	3,300	1.1	1.6	1.4	1.9	2.1	1.4	1.3	0.5	11.3
Dry Beans	9,370	1.4	1.7	1.3	4.4	4.8	2.2	2.0	1.4	19.2
Misc. Field	4,650	0.8	0.9	0.9	2.3	2.9	1.9	0.8	0.8	11.3
Alfalfa	54,480	14.5	22.2	20.0	29.5	34.1	29.5	22.2	15.4	187.4
Pasture	40,920	12.3	18.4	16.4	23.6	26.2	21.8	16.1	11.6	146.4
Asparagus	19,770	3.1	3.6	1.6	5.8	12.7	10.6	7.8	3.9	49.1
Potatoes	2,600	0.4	0.5	0.4	0.9	1.6	1.2	0.6	0.4	6.0
Tomatoes	49,280	7.8	9.0	10.7	16.5	33.6	24.6	9.4	7.8	119.4
Misc. Truck	5,710	0.9	1.5	2.2	3.2	3.5	2.4	1.8	0.9	16.4
Fruit & Nuts	23,780	5.3	7.6	7.9	12.1	14.7	12.1	8.5	5.2	73.4
Vineyards	3,240	0.6	0.6	0.8	1.5	1.8	1.5	0.9	0.7	8.4
Fallow 3/	4,350	0.4	0.1	0.4	0	0	0	0.2	0	1.1
Total Irrigated (Single Crop)	503,510	111.7	147.4	134.0	217.8	260.4	198.8	129.4	92.3	1,291.8
Irrigated (Double Crop)[4/]										
Sugar Beets	0	0	0	0	0	0	0	0	0	0
Field Corn	4,860	1.8	2.3	1.2	0.7	1.8	2.6	2.4	1.1	13.9
Milo (Grain Sorghum)	900	0.3	0.4	0.2	0.1	0.2	0.4	0.4	0.1	2.1
Sudan	940	0.4	0.4	0.2	0.3	0.6	0.4	0.4	0.2	2.9
Dry Beans	1,320	0.5	0.6	0.4	0.4	0.8	0.4	0.1	0.2	3.4
Tomatoes	260	0.1	0.1	0	0	0.1	0.1	0.1	0	0.5
Potatoes	0	0	0	0	0	0	0	0	0	0
Lettuce	760	0.3	0.4	0.2	0.3	0.5	0.3	0.3	0.2	2.5
Misc. Truck	40	0	0	0	0	0	0	0	0	0
Misc. Field	180	0.1	0.1	0	0.1	0.1	0.1	0.1	0.1	0.7
Total Irrigated (Double Crop)	9,260	3.5	4.3	2.2	1.9	4.1	4.3	3.8	1.9	26.0
Total Irrigated	512,770	115.2	151.7	136.2	219.7	264.5	203.1	133.2	94.2	1,317.8
Nonirrigated										
Fruit & Nuts	830	0.1	0	0.1	0	0	0	0	0	0.2
Vineyard	90	0	0	0	0	0	0	0	0	0
Grain	1,120	0.1	0	0.1	0.1	0	0	0	0	0.3
Fallow	520	0	0	0	0	0	0	0	0	0
Total Nonirrigated	2,560	0.2	0	0.2	0.1	0	0	0	0	0.5
TOTAL AGRICULTURAL	515,330	115.4	151.7	136.4	219.8	264.5	203.1	133.2	94.2	1,318.3
NONAGRICULTURAL										
Native Vegetation[5/6/]	66,910	13.9	5.5	10.5	2.9	2.3	2.2	5.3	3.0	45.6
Riparian Vegetation	9,190	3.4	5.7	5.1	7.4	9.1	7.4	5.3	3.3	46.7
Water Surface	54,220	20.3	33.4	29.8	43.9	53.3	43.9	31.6	19.4	275.6
Urban 7/	32,530	4.7	4.5	5.0	5.1	5.5	4.6	4.1	2.8	36.3
TOTAL NONAGRICULTURAL	162,850	42.3	49.1	50.4	59.3	70.2	58.1	46.3	28.5	404.2
GRAND TOTAL	678,180	157.7	200.8	186.8	279.1	334.7	261.2	179.5	122.7	1,722.5

1/ Delta Service Area as shown on Plate 2.
2/ Excludes 9,260 acres of irrigated grain on double cropped land (see Footnote 4).
3/ Lands normally irrigated, left fallow.
4/ An additional 9,260 acres of grain were grown as a first crop.
5/ Includes 62,353 acres of native vegetation, 1,057 acres idle land, and 3,474 acres of semiagricultural.
6/ Adjusted to conform with 1976 acreages.
7/ Includes 31,162 acres urban, 734 acres recreational, and 634 acres lawn areas.

Metric Conversion: Thousands of acre-feet times 1.2335 equals cubic hectometres.
Acres times 0.40469 equals hectares.

TABLE 13

COMPUTED DELTA OUTFLOW[1/]
JANUARY 1965-NOVEMBER 1977
(In cfs)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1965	132,300	55,700	27,800	56,600	32,300	16,200	5,900	8,400	12,900	15,100	27,300	30,800
1966	43,500	35,500	24,000	18,900	9,900	2,500	3,200	4,800	6,900	6,600	21,800	60,100
1967	62,500	81,100	55,700	75,200	73,900	61,200	24,000	9,700	16,500	16,700	16,500	20,200
1968	25,800	50,300	39,700	9,700	6,700	3,600	3,700	5,200	6,000	5,500	10,500	25,700
1969	121,100	155,800	91,800	69,200	64,300	46,600	13,100	12,400	20,200	19,500	20,000	46,500
1970	188,400	108,800	55,000	11,000	10,800	6,200	5,300	7,900	14,600	13,500	27,700	83,700
1971	63,800	34,100	31,500	36,800	26,600	21,200	11,800	13,100	19,800	14,000	13,900	24,000
1972	21,300	21,900	18,200	7,600	5,400	3,100	6,400	6,600	10,800	11,800	25,900	27,100
1973	101,800	102,700	75,500	21,700	11,900	7,300	4,800	6,100	11,300	14,100	60,000	76,500
1974	137,400	58,500	75,200	107,500	25,600	17,100	9,500	12,900	21,100	19,100	23,400	28,100
1975	17,300	57,300	66,800	34,500	28,800	22,700	11,200	9,500	13,400	16,900	17,900	20,000
1976	9,400	7,500	7,800	8,700	3,900	3,800	4,200	4,400	3,300	3,600	3,700	4,300
1977	4,900	4,900	2,500	2,600	3,400	2,100	2,300	2,900	3,100	2,300	4,200	

Metric Conversion: Cubic feet per second times 0.028317 equals cubic metres per second.

1/ Computed by the Delta Branch from measured Delta inflow reduced by the exportations, the average evapotranspiration and changes in soil moisture in the Delta Service Area, which were developed by Delta Studies in the early 1960s. Outflows are adjusted for precipitation recorded at Stockton Fire Station No. 4. Outflows for March through October of 1977, were computed using 1977 data of evapotranspiration and soil moisture and as shown on Table 17.

TABLE 14

SALINITY OBSERVATIONS - 1977

Western Delta

No.	Station	Milligrams per Litre - Chloride[1/]							
		Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
1	Sacramento River, Chipps Island	6,654 3,724	7,294 3,986	7,797 3,881	8,807 4,669	8,713 4,549	7,971 4,392	7,944 4,661	8,216 4,614
2	Sacramento River, Pittsburg	4,602 2,865	4,690 2,789	4,785 2,776	4,998 3,205	6,863[2/] 3,916	6,863[2/] 3,095	6,863[2/] 3,804	6,863[2/] 3,543
3	Sacramento River, Collinsville	3,903 2,135	4,634 1,815	4,651 1,460	5,144 1,820	5,331 2,450	4,881 2,585	5,144 2,480	4,940 2,660
4	San Joaquin River at Antioch	3,010 1,339	3,042 1,257	3,333 1,170	4,042 1,555	3,916 1,519	3,682 1,417	3,892 2,013	3,791 1,721
5	San Joaquin River at Blind Point	1,738 533	1,930 634	2,284 581	2,649 635	2,639 629	2,651 664	2,581 748	2,704 811
6	Sacramento River at Emmaton	1,820 528	2,396 774	2,320 356	3,346 445	3,213 728	2,970 797	3,024 944	3,310 1,467
7	San Joaquin River at Jersey Pt.	1,170 465	1,303 448	1,305 375	1,861 576	2,157 695	2,221 660	2,278 753	1,880 679
8	Sacramento River below Rio Vista	166 26	221 37	197 26	252 59	673 66	819 127	1,544 168	1,044 290
9	San Joaquin River at San Andreas	212 26	219 26	183 17	315 43	344 25	261 45	303 35	301 45

1/ All chloride values are derived from correlation to electrical conductivity measurements. Quantities are high reading for the month and corresponding low reading for the same day.

2/ Electrical conductivity exceeded maximum capacity of instrument (20,000 microsiemens).

TABLE 15

SUMMARY OF MONTHLY STREAMFLOW, DIVERSIONS, AND ACCRETIONS - 1977

SACRAMENTO RIVER

	River Mile Above Sacramento	Acre-Feet March	April	May	June	July	August	Sept.	October	Total
Shasta Lake										
Computed Inflow		245,440	200,060	223,320	195,410	180,100	197,000	235,960	231,090	1,708,380
Change in Storage		-24,900	-246,600	-87,000	-189,400	-257,200	-102,500	+52,600	+25,400	-829,600
Keswick Reservoir										
Imported from Trinity Div.		71,030	44,880	152,930	176,300	227,400	224,700	95,810	16,300	1,009,350
Release		333,350	474,280	451,910	555,130	656,050	512,960	273,530	215,930	3,473,140
Sacramento River at Keswick	250.5R	333,800	480,200	456,900	568,400	665,300	522,900	271,600	211,000	3,510,100
Clear Creek near Igo		3,150	3,010	3,550	2,940	3,020	3,070	2,260	2,390	23,390
Cow Creek near Millville		7,250	3,750	8,360	1,080	39	46	2,620	2,620	25,765
Battle Creek near Coleman F.H.		16,360	13,750	16,360	13,300	12,330	11,750	12,320	12,590	108,760
Cottonwood Creek near Cottonwood		8,970	8,100	10,150	4,430	3,051	2,880	5,380	5,772	48,733
Unmeasured Accretions		25,459	16,667	25,115	7,153	13,622	11,731	39,558	20,846	160,151
Diversions		2,089	23,177	8,235	28,903	30,862	27,177	17,038	13,218	150,699
Sacramento River near Red Bluff	209.7	392,900	502,300	512,200	568,400	666,500	525,200	316,700	242,000	3,726,200
Red Bank Creek near Red Bluff		444	25	511	0	0	0	28	0	1,008
Fish Water Release, Coyote Creek		7,962	7,740	12,815	8,990	1,490	1,958	0	2,933	43,888
Antelope Creek near Red Bluff[1/]		1,110	800	1,130	220	0	10	270	654	4,194
Mill Creek near Los Molinos[1/]		2,160	2,230	3,130	3,490	0	0	690	630	12,330
Elder Creek near Paskenta[2/]		0	0	0	0	0	0	0	0	0
Thomas Creek near Paskenta[2/]		0	0	0	0	0	0	0	0	0
Deer Creek near Vina[1/]		2,860	2,070	2,410	660	0	0	360	580	8,940
Unmeasured Accretions		4,560	3,701	5,435	-3,943	-4,283	2,551	-21,452	-10,872	-24,303
Diversions		8,796	16,466	17,431	41,417	32,607	12,319	6,296	7,325	142,657
Sacramento River near Vina Bridge	166.5R	403,200	502,400	520,200	536,400	631,100	517,400	290,300	228,600	3,629,600
Unmeasured Accretions		-1,248	-11,421	1,454	7,858	9,944	-18,863	-1,786	-1,987	-16,049
Diversions		47,852	109,079	80,654	111,358	117,244	100,037	29,714	22,013	617,951
Sacramento River at Hamilton City	149.5L	354,100	381,900	441,000	432,900	523,800	398,500	258,800	204,600	2,995,600
Stoney Creek near Orland[3/]		0	0	0	0	0	0	0	0	0
Mud Creek near Chico		85	29	148	0	26	47	47	0	382
Big Chico Creek at Chico		1,359	768	839	124	0	0	163	199	3,452
Unmeasured Accretions		9,829	-2,687	-8,790	-9,544	-12,767	4,135	3,651	18,115	1,942
Diversions		673	1,610	2,797	3,080	3,759	3,382	561	14	15,876
Sacramento River at Ord Ferry	130.8R	364,700	378,400	430,400	420,400	507,300	399,300	262,100	222,900	2,985,500
Unmeasured Accretions		-17,701	-9,463	4,253	-3,383	11,857	3,169	2,307	-17,476	-26,437
Diversions		3,999	17,937	9,853	17,217	15,257	12,969	3,907	1,124	82,263

1/ Observed zero flow at mouth July 20, 1977. Other months adjusted accordingly for computing accretions. Flow at gage listed in Table 6.
2/ 100 percent of flow intercepted by Tehama-Colusa Canal. Flow at gage listed in Table 6.
3/ 100 percent of flow intercepted by Glenn-Colusa Canal. Flow at gage listed in Table 6.

Metric Conversion: Acre-feet times 1233.5 equals cubic metres.
Miles times 1.6093 equals kilometres.

TABLE 15 (Cont'd)

SUMMARY OF MONTHLY STREAMFLOW, DIVERSIONS, AND ACCRETIONS - 1977

SACRAMENTO RIVER

	River Mile Above Sacramento	Acre-Feet March	April	May	June	July	August	Sept.	October	Total
Sacramento River at Butte City	115.8L	343,000	351,000	424,800	399,800	503,900	389,500	260,500	204,300	2,876,800
Unmeasured Accretions		25,597	12,814	4,013	-3,968	-9,993	5,868	1,167	2,731	38,229
Diversions		8,797	20,714	25,413	24,332	24,907	16,368	4,467	6,231	131,229
Sacramento River at Colusa	89.4R	359,800	343,100	403,400	371,500	469,000	379,000	257,200	200,800	2,783,800
Butte Slough Outfall	84.0L	0	0	708	0	0	0	0	0	708
R.D. 70 Drain	68.8L	637	595	801	378	97	190	470	202	3,370
Unmeasured Accretions		-16,562	-13,317	-2,592	672	-5,710	-1,867	6,728	5,994	-26,654
Diversions		27,075	67,378	49,617	76,150	72,187	56,123	22,498	2,296	373,324
Sacramento River below Wilkins Slough	62.9R	316,800	263,000	352,700	296,400	391,200	321,200	241,900	204,700	2,387,900
R.D. 108 Drain	53.8R	1,857	1,916	5,774	6,163	1.906	5,738	8,450	541	32,345
R.D. 787 Drain	37.0R	501	225	1,068	1,022	645	1,499	671	195	5,826
Sycamore Slough (R.D. 787)		0	0	248	496	0	4	219	0	967
Colusa Basin Drain	34.1R	7,200	589	29,750	83	149	18,540	27,990	778	85,079
Unmeasured Accretions		34,279	19,040	2,261	14,764	17,888	26,660	14,074	12,162	141,128
Diversions		11,937	23,570	19,701	28,428	21,988	17,241	6,304	1,976	131,145
Sacramento River at Knights Landing	34.0L	348,700	261,200	372,100	290,500	389,800	356,400	287,000	216,400	2,522,100
Sacramento Slough	21.2L	21,200	13,820	34,030	12,900	11,290	16,940	26,870	10,490	147,540
Feather River at Nicolaus		72,330	124,900	64,640	71,750	110,700	94,630	76,270	68,880	684,100
Natomas Cross Canal at Head		0	0	0	0	0	0	0	0	0
R.D. 1000 Drain No. 4		0	0	0	0	0	0	0	0	0
R.D. 1001 Drain		90	272	300	0	103	0	296	49	1,110
Unmeasured Accretions		-21,968	-20,294	2,661	-19,766	-30,292	-29,061	-10,864	-5,201	-134,785
Diversions[4/]		6,452	11,698	16,731	15,884	18,701	13,909	4,672	118	88,165
Sacramento River at Verona	19.6L	413,900	368,200	457,000	339,500	462,900	425,000	374,900	290,500	3,131,900
R.D. 1000 Drain No. 6 (Prichard Lake)		0	0	0	0	0	0	940	0	940
R.D. 1000 Drain No. 3	6.85L	1,676	430	2,209	0	0	0	3,032	0	7,347
R.D. 1000 Drain (2nd Bannon Slough)		0	0	0	0	0	0	0	110	110
Natomas East Main Drain		2,142	603	2,251	228	213	270	937	359	7,003
American River at Sacramento	1.1L	17,880	13,830	30,380	62,910	50,460	48,490	32,070	16,120	272,140
Unmeasured Accretions		-20,164	-4,864	-6,764	31,420	19,263	19,263	1,950	-17,706	22,398
Diversions		11,234	23,499	17,976	25,558	25,636	20,423	6,929	6,083	137,338
Sacramento River at Sacramento	0.6L	404,200	354,700	467,100	408,500	507,200	472,600	406,900	283,300	3,304,500
TOTAL MEASURED ACCRETIONS		177,223	199,452	231,562	191,164	195,519	206,062	202,353	126,092	1,529,427
TOTAL UNMEASURED ACCRETIONS		22,081	-9,824	27,046	21,263	9,529	23,586	35,333	6,606	135,620
TOTAL ACCRETIONS		199,304	189,628	258,608	212,427	205,048	229,648	237,686	132,698	1,665,047
TOTAL DIVERSIONS[4/]		128,904	315,128	248,408	372,327	363,148	279,948	102,386	60,398	1,870,647

4/ Includes diversions from Feather River below Nicolaus.

Metric Conversion: Acre-feet times 1233.5 equals cubic metres.
Miles times 1.6093 equals kilometres.

TABLE 16

SUMMARY OF MONTHLY STREAMFLOW, DIVERSIONS, AND ACCRETIONS - 1977

FEATHER RIVER

	River Mile	Acre-Feet								
		Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Total
Oroville Reservoir										
Computed Inflow		74,315	60,553	72,229	46,701	42,763	98,419	100,448	61,231	556,659
Change in Storage		-7,917	-157,668	-53,416	-150,457	-206,081	-105,052	23,340	-9,836	667,087
Oroville Reservoir Release[1]	70.4	80,072	213,780	122,103	191,043	242,113	197,801	72,828	67,892	1,187,632
Change in Storage of Thermalito Complex Reservoirs		-6,024	11,827	-9,322	2,157	4,366	8,037	-18,805	-3,187	-10,951
Kelley Ridge Power Plant Inflow		0	60	0	647	187	102	341	331	1,668
Unmeasured Accretions[2]		64	5,231	-1,780	-154	4,769	1,311	-1,857	-3,294	4,290
Diversions[2]		26,871	59,837	71,375	107,411	119,198	94,592	20,342	12,419	512,045
Release Through Thermalito Diversion Dam	65.6	24,990	23,869	24,523	24,242	24,887	24,995	23,784	46,753	218,043
Thermalito Afterbay Rel. to River		34,299	123,538	33,747	57,726	98,618	71,590	45,991	8,944	474,453
Feather River Below Thermalito Afterbay[3]	58.2	59,289	147,407	58,270	81,968	123,505	96,585	69,775	55,697	692,496
Unmeasured Accretions		-1,974	-12,829	-8,127	-13,507	-11,672	-5,734	-2,868	-3,255	-59,966
Diversions		165	378	393	351	433	351	107	22	2,200
Feather River near Gridley	49.7	57,150	134,200	49,750	68,110	111,400	90,500	66,800	52,420	630,330
Cox Spillway		0	0	0	601	1,164	1,369	413	0	3,547
North Honcut Creek near Bangor[5]		0	0	0	0	0	0	0	0	0
South Honcut Creek[5]		0	0	0	0	0	0	0	0	0
Jack Slough near Marysville		118	534	5,012	1,539	2,275	5,651	5,508	2,911	23,548
Yuba River near Marysville	27.3L	11,530	10,290	10,220	9,210	5,430	4,410	5,110	15,950	72,150
Unmeasured Accretions		928	-3,119	9,049	5,115	4,704	-3,197	-3,714	-3,205	6,561
Diversions[4]		2,226	10,805	12,031	8,825	8,773	3,483	1,857	1,186	49,186
Feather River Below Shanghai Bend	23.0	67,500	131,100	62,000	75,750	116,200	95,250	72,260	66,890	686,950
Bear River near Wheatland[5]		0	0	0	0	0	0	0	0	0
Unmeasured Accretions		7,621	737	9,073	4,470	4,536	5,126	7,315	3,168	42,046
Diversions		2,791	6,937	6,433	8,470	10,036	5,746	3,305	1,178	44,896
Feather River at Nicolaus	8.0	72,330	124,900	64,640	71,750	110,700	94,630	76,270	68,880	684,100
TOTAL MEASURED ACCRETIONS		17,672	-943	24,554	9,840	4,690	3,495	30,177	22,379	111,864
TOTAL UNMEASURED ACCRETIONS		6,639	-9,980	8,215	-4,076	2,337	-2,494	-1,124	-6,586	-7,069
TOTAL ACCRETIONS		24,311	-10,923	32,769	5,764	7,027	1,001	29,053	15,793	104,795
TOTAL DIVERSIONS[6]		32,053	77,957	90,232	125,057	138,440	104,172	25,611	14,805	608,327

1/ Net release - does not include amounts pumped back.
2/ All major diversions from Thermalito Afterbay.
3/ Releases from Thermalito Afterbay and Thermalito Diversion Dam.
4/ Includes diversions along Yuba River between its mouth and gaging station, Yuba River near Marysville.
5/ These streams are listed as zero for the computation of unmeasured accretions since most of their flow did not reach the Feather River. Values at these stations are listed in Table 6.
6/ Diversions below Nicolaus included in Table 15.

Metric Conversion: Acre-feet times 1233.5 equals cubic metres.
Miles times 1.6093 equals kilometres.

TABLE 17

SUMMARY OF MONTHLY WATER SUPPLY AND WATER USE - 1977

DELTA SERVICE AREA

Item	Thousands of Acre-Feet							
	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
Water Supply								
Delta Tributary Streams	440.1	369.2	494.4	417.7	515.7	482.5	419.6	299.2
Precipitation on Delta Service Area	70.3	21.3	83.8	4.2	0.4	0	32.4	7.9
Urban Requirement Imported or From Wells	4.7	4.5	5.0	5.1	5.5	4.6	4.1	2.8
Total	515.1	395.0	583.2	427.0	521.6	487.1	456.1	309.9
Water Use								
Consumptive Use	157.7	200.8	186.8	279.1	334.7	261.2	179.5	122.7
Exportation	230.0	81.8	182.1	47.6	51.5	92.5	120.8	52.1
Total	387.7	282.6	368.9	326.7	386.2	353.7	300.3	174.8
Change in Soil Moisture								
Uplands	-1.5	-14.5	13.0	6.4	-3.4	-11.5	-12.9	-12.5
Lowlands	-23.6[1/]	-26.0	-10.7	-29.0	-5.4	-33.4	-16.1	5.5
Total	-25.1	-40.5	2.3	-22.6	-8.8	-44.9	-29.0	-7.0
Computed Surface Outflow	152.5	152.9	212.0	122.9	144.2	178.3	184.8	142.1
Mean Cubic Feet Per Second	2,500	2,600	3,400	2,100	2,300	2,900	3,100	2,300

1/ Includes 11,000 Acre-Feet of leach water returned to channels and based on 7,300 ponded acres remaining on February 26, 1977.

Metric Conversion: Thousands of Acre-Feet times 1.2335 equals cubic hectometres.
Cubic feet per second times 0.08317 equals cubic metres per second.

TABLE 18

MONTHLY DIVERSIONS[1/]
SACRAMENTO RIVER ABOVE SACRAMENTO
1972-1977

Year	Runoff in % of Normal (Sacramento River at Sacramento)		Thousands of Acre-Feet Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Total
1972	79	Monthly Diversions	[2/]	321	439	434	432	366	184	45	2,221
		% of Season Total		14.5	19.8	19.5	19.4	16.5	8.3	2.0	
1973	118	Monthly Diversions	[2/]	176	471	420	419	369	171	73	2,099
		% of Season Total		8.4	22.4	20.0	20.0	17.6	8.1	3.5	
1974	189	Monthly Diversions	[2/]	140	481	463	442	403	168	106	2,203
		% of Season Total		6.4	21.8	21.0	20.1	18.3	7.6	4.8	
1975	111	Monthly Diversions	[2/]	208	465	489	456	407	160	98	2,283
		% of Season Total		9.1	20.4	21.4	20.0	17.8	7.0	4.3	
1976	48	Monthly Diversions	180[3/]	342	480	456	449	358	162	77	2,504
		% of Season Total	7.2	13.7	19.2	18.2	17.9	14.2	6.5	3.1	
1977	30	Monthly Diversions	128	314	244	371	360	279	102	60	1,858
		% of Season Total	6.9	16.9	13.1	20.0	19.4	15.0	5.5	3.2	

1/ For 1972 through 1975, diversions were based on USBR measurements of major diverters and estimates of small diverters.

2/ March diversions not available.

3/ Based on comparisons of historical diversions during March, this figure was adjusted down from that published in 1976 Sacramento Valley Water Use Survey.

Metric Conversion: 1,000 acre-feet times 1.2335 equals cubic hectometres.

TABLE 19

UNMEASURED ACCRETIONS SACRAMENTO RIVER
FROM KESWICK TO SACRAMENTO - 1947-1977

Year	Percent of Average Runoff[1]	Thousands of Acre-Feet								
		April	May	June	July	Aug.	Sept.	Oct.	April-Oct. Totals	July-Sept. Totals[2]
1947	61	375[3]	121[3]	123	64	72	463	22	1,240	599
1948	92	637[3]	832[3]	339	135	64	125	79	2,211	324
1949[5]	70	251	209	98	85	60	27	41	771	172
1950[5]	85	247	155	122	112	77	67	12	792	256
1951[4]	134	190	188	116	1	52	122	-1	668	175
1952[4]	167	198	304	278	73	42	46	41	982	161
1953[4]	118	-34	209	115	52	57	51	48	498	160
1954[4]	102	390	197	73	40	17	78	64	859	135
1955[5]	64	90	123	68	39	63	48	39	470	150
1956[4]	175	130	100	86	48	66	75	84	589	189
1957	87	132[3]	101	51	25	31	24	62	426	80
1958	174	1,009[3]	271	160	73	10	30	35	1,588	113
1959[5]	71	129	79	33	1	40	101	26	409	142
1960[5]	76	75	91	-12	-20	-12	5	16	143	-27
1961[5]	70	102	56	6	-26	-3	21	-15	141	-8
1962	88	18[3]	36	14	-12	-18	11	59	108	-19
1963[4]	135	331[3]	114	67	12	-5	-15	68	572	-8
1964[5]	64	33	27	12	-11	9	-15	-12	43	-17
1965[4]	150	218	46	72	-21	-15	-27	-9	264	-63
1966[5]	76	25	27	-30	-48	-36	19	6	-37	-65
1967[4]	141	356	73	201	7	-33	12	46	662	-14
1968[5]	80	69	12	-4	13	96	30	76	292	139
1969[4]	157	69	-38	16	-5	-45	40	38	75	-10
1970	140									
1971	133									
1972[5]	79	51	65	28	33	13	4	1	195	50
1973[4]	118	129	90	63	9	36	46	46	419	91
1974	189	1,018[3]	154	105	59	11	43	9	1,399	113
1975	111	306	24	47	-24	-25	43	60	431	-6
1976	48	66	5	-9	-27	1	18	22	76	-8
1977	30	-10	27	21	10	24	35	7	114	69

1/ Sacramento River at Sacramento.
2/ July through September represents the summer months.
3/ Floodflows in Sutter and/or Yolo Bypasses.
4/ Used in computation of above normal line on Plate 12.
5/ Used in computation of below normal line on Plate 12.

Metric Conversion: Thousands of acre-feet times 1.2335 equals cubic hectometres.

TABLE 20

COMPARISON OF PERCENTAGE OF NONPROJECT WATER AVAILABILITY AND ASSUMED RIPARIAN WATER USE

Water Availability	Percent of Normal Demand June	July	Aug.	Sept.
Forecast of Supply for Full Riparian Needs (SWRCB) 1/	60	45	50	85 2/
Forecast of Supply for Full Riparian Needs (SWRCB) 3/	60	40	55	85
Actual Supply to Meet Full Riparian Needs (DWR) 4/	97	60	69	100
Supply for Crops After Riparian Channel Losses & Delta Outflow Have Been Satisfied 5/	95	29	30	100
Water Use By Crops				
Sacramento River System Above Sacramento 6/	70	67	77	75
Delta Agriculture 7/	83	105	104	109

1/ Based on the forecasted natural runoff by "California Cooperative Snow Survey", Bulletin 120-77, Report No. 2, March 1, 1977. Monthly riparian demand was from 1976 data in the "Sacramento Valley Water Use Survey Report", June 1977.

2/ Not originally forecast, but computed for this report.

3/ Based on the forecasted natural runoff by "California Cooperative Snow Survey", Bulletin 120-77, Report No. 4, May 1, 1977. Monthly normal riparian demand was from 1976 data in the "Sacramento Valley Water Use Survey Report", June 1977.

4/ Actual water supply determined by eliminating project effects from the recorded measurements of flow. Assumed full riparian demand from Table 22.

5/ Assumes evaporation from water surfaces and uses by riparian vegetation cannot take a shortage of water supply and Delta salinity should not be allowed to intrude into the Delta beyond the limits allowed during 1977 (see Table 22).

6/ These percentages were determined by dividing the Assumed Riparian Water Use Total for the Sacramento, Feather, Yuba, and American Rivers in Table 21 by the Sacramento River System Crops in Table 22.

7/ Determined by dividing the computed assumed riparian water use for Delta Agriculture, Total in Table 21 by the comparable figures shown in Table 22.

TABLE 21

ESTIMATED NONPROJECT RUNOFF AND ASSUMED RIPARIAN USE IN THE SACRAMENTO VALLEY AND THE DELTA
(Quantities in 1,000's Acre-Feet)

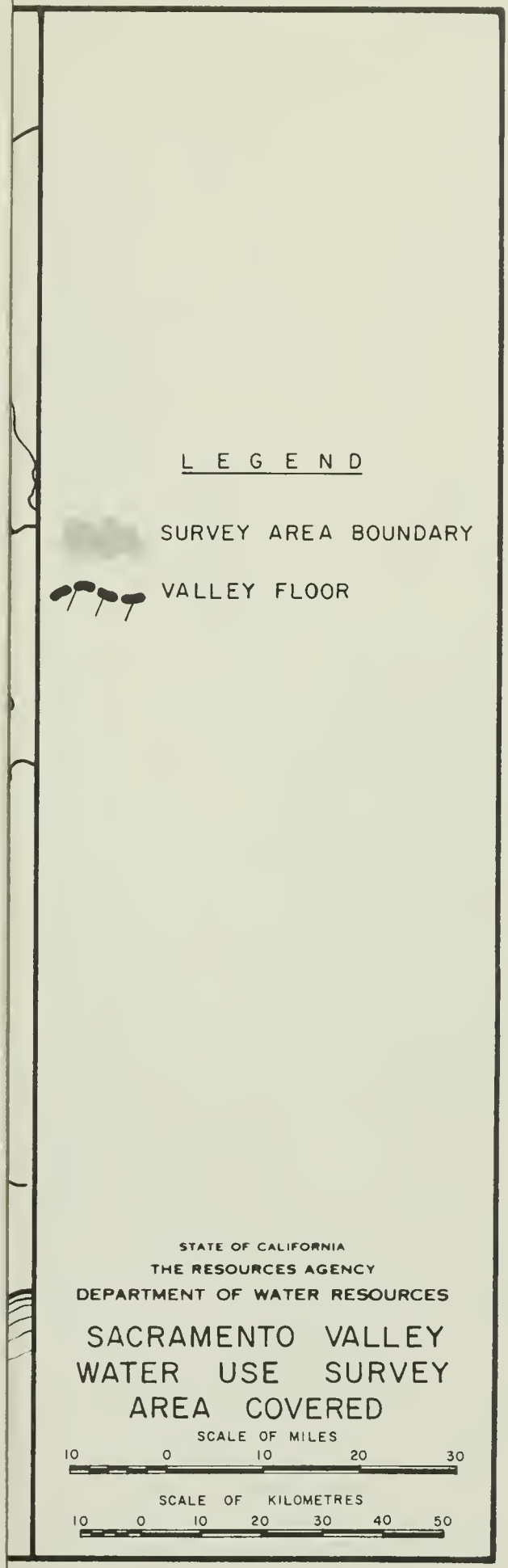
Nonproject Water Supply	Mar.	Apr.	May	June	July	Aug.	Sept.
Sacramento River Above Bend Bridge	306	252	303	237	228	223	274
Feather River at Oroville	98	96	117	65	45	46	49
American River at Fair Oaks	43	76	99	54	0	0	1
Yuba River Near Smartville	35	65	85	38	9	4	9
Unmeasured Accretions 4 Rivers	-1	-51	11	9	-2	3	-6
Total Natural Flow Sacto. Valley	481	438	615	403	280	276	327
San Joaquin River at Vernalis 1/	32	13	25	7	6	8	11
Eastside Streams	3	1	2	2	2	2	1
Total Nonproject Runoff Available to Sacramento Valley and Delta	516	452	642	412	288	286	339
Assumed Riparian Water Use							
Sacramento River 2/	18	44	36	52	50	41	18
Feather River	5	6	11	11	14	10	5
Yuba River	1E	1E	2E	2E	2E	1E	1E
American River	0	0	0	2E	2E	2E	0
Delta Agriculture, Uplands 3/	4	6	7	16	17	11	5
Delta Agriculture, Lowlands	24	67	38	116	172	103	54
Delta Agriculture, Total	(28)	(73)	(45)	(132)	(189)	(114)	(59)
Delta Water Surfaces, Riparian & Native Vegetation 4/	14	37	24	53	65	53	34
Delta Outflow 5/	152	153	212	123	144	178	185
Total Assumed Riparian Use	218	314	330	375	466	399	302
Excess Nonproject Runoff Available For Other Uses	298	138	312	37			37
Assumed Riparian Use of Project Water					178	113	
Appropriative Use in Delta Uplands	14	24	30	62	67	45	21
Remaining Excess Nonproject Runoff Available for Export & Other Appropriators	284	114	282				16
Total Use of Project Water by Riparians and Delta Appropriators				25	245	158	

E = Estimated
1/ Actual measured flow by U. S. Geological Survey.
2/ City of Sacramento to Red Bluff.
3/ Assumed riparian use is 20 percent of total upland use.
4/ Urban use was supplied from deep wells and not included in Assumed Riparian Water Use.
5/ From Table 17.

TABLE 22
ESTIMATED NONPROJECT RUNOFF AND ASSUMED FULL RIPARIAN DEMAND
IN THE SACRAMENTO VALLEY AND THE DELTA
(Quantities in 1,000's Acre-Feet)

	Mar.	Apr.	May	June	July	Aug.	Sept.
Nonproject Water Supply Available to Sacramento Valley and Delta 1/	516	452	642	412	288	286	339
Assumed Full Riparian Demand							
Sacramento River System Crops 2/	32	78	64	92	92	69	32
Delta Agriculture, Uplands 3/4/	1	4	9	17	16	11	4
Delta Agriculture, Lowlands 3/	0	40	56	140	164	103	51
Delta Agriculture, Total 3/	(1)	(44)	(65)	(157)	(180)	(114)	(55)
Delta Water Surfaces, Riparian & Native Vegetation 5/	14	37	24	53	65	53	34
Delta Outflow 6/	152	153	212	123	144	178	185
Total Assumed Full Riparian Demand	199	312	365	425	481	414	306
Percentage of Full Riparian Demand That can be Met From Available Supply	100	100	100	97	60	69	100
Excess Nonproject Runoff Available After Satisfying Delta Outflow & Delta Water Surfaces, Nat. Veg. etc.	350	262	406	236	79	55	120
Demand for Crops (Sacramento River and Delta)	33	122	129	249	272	183	87
Percent of Assumed Full Riparian Demand of Crops in the Sacramento River System & Delta That can be Met with the Net Nonproject Supply Available	100	100	100	95	29	30	100

1/ See Table 21 for contributions from individual sources.
2/ Data from SWRCB and adjusted for 1977 demand curve.
3/ Data from the SVWUS Report for 1976 and adjusted for soil moisture change.
4/ Assumed riparian use is 20 percent of total upland use.
5/ Urban use was supplied from deep wells and not included in Assumed Full Riparian Demand.
6/ From Table 17.


LEGEND
SURVEY AREA BOUNDARY
VALLEY FLOOR
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SACRAMENTO VALLEY
WATER USE SURVEY
AREA COVERED
SCALE OF MILES
10 0 10 20 30
SCALE OF KILOMETRES
10 0 10 20 30 40 50

LASSEN
PLUMAS
SIERRA
NEVADA
PLACER
EL DORADO
AMADOR
CALAVERAS
TUOLUMNE
STANISLAUS
MERCED
SHASTA
TEHAMA
GLENN
BUTTE
COLUSA
SUTTER
YUBA
NEVADA
SACRAMENTO
SAN JOAQUIN
YOLO
SOLANO
NAPA
SONOMA
LAKE
CONTRA COSTA
ALAMEDA
MARIN
SAN FRANCISCO
Susanville
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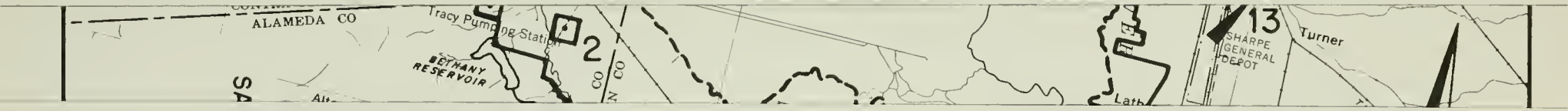
Lake Tahoe
Nevada City
Placerville
Auburn
Folsom Lake
Jackson
San Andreas
New Melones Res.
Sonora
New Don Pedro Res.
Modesto
Merced
Tuolumne R.
Stanislaus R.
San Joaquin R.
Pardee Res.
Mokelumne R.
Cosumnes R.
American R.
Lake Almanor
Feather River
Lake Oroville
Marysville
Yuba City
Oroville
Sacramento
Stockton
Pit River
Shasta Lake
Redding
Red Bluff
Willows
Colusa
Woodland
Fairfield
Vacaville
Martinez
Oakland
Napa
Lake Berryessa
Clear L.
Santa Rosa
San Rafael
Redwood City
Clair Engle L.
LEGEND
SURVEY AREA BOUNDARY
VALLEY FLOOR
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SACRAMENTO VALLEY
WATER USE SURVEY
AREA COVERED
SCALE OF MILES
10 0 10 20 30
SCALE OF KILOMETRES
10 0 10 20 30 40 50


ALAMEDA CO
Tracy Pumping Station
BETHANY RESERVOIR
2
CO
13
SHARPE GENERAL DEPOT
Turner

LEGEND

DELTA SERVICE AREA

STREAM GAGING STATIONS

1 Sacramento River at Sacramento
2 Yolo Bypass Near Woodland
3 S. F. Putah Creek Near Davis
4 Morrison Creek Near Sacramento
5 Cosumnes River at McConnell
6 Dry Creek Near Galt
7 Mokelumne River at Woodbridge
8 Bear Creek Near Lodi
9 Mosher Slough Near Stockton
10 Calaveras River Near Stockton
11 Stockton Diverting Canal at Stockton
12 Duck Creek Near Stockton
13 French Camp Slough Near French Camp
14 San Joaquin River at Vernalis
15 Marsh Creek Near Byron

DELTA LOWLANDS

SALINITY OBSERVATION STATIONS

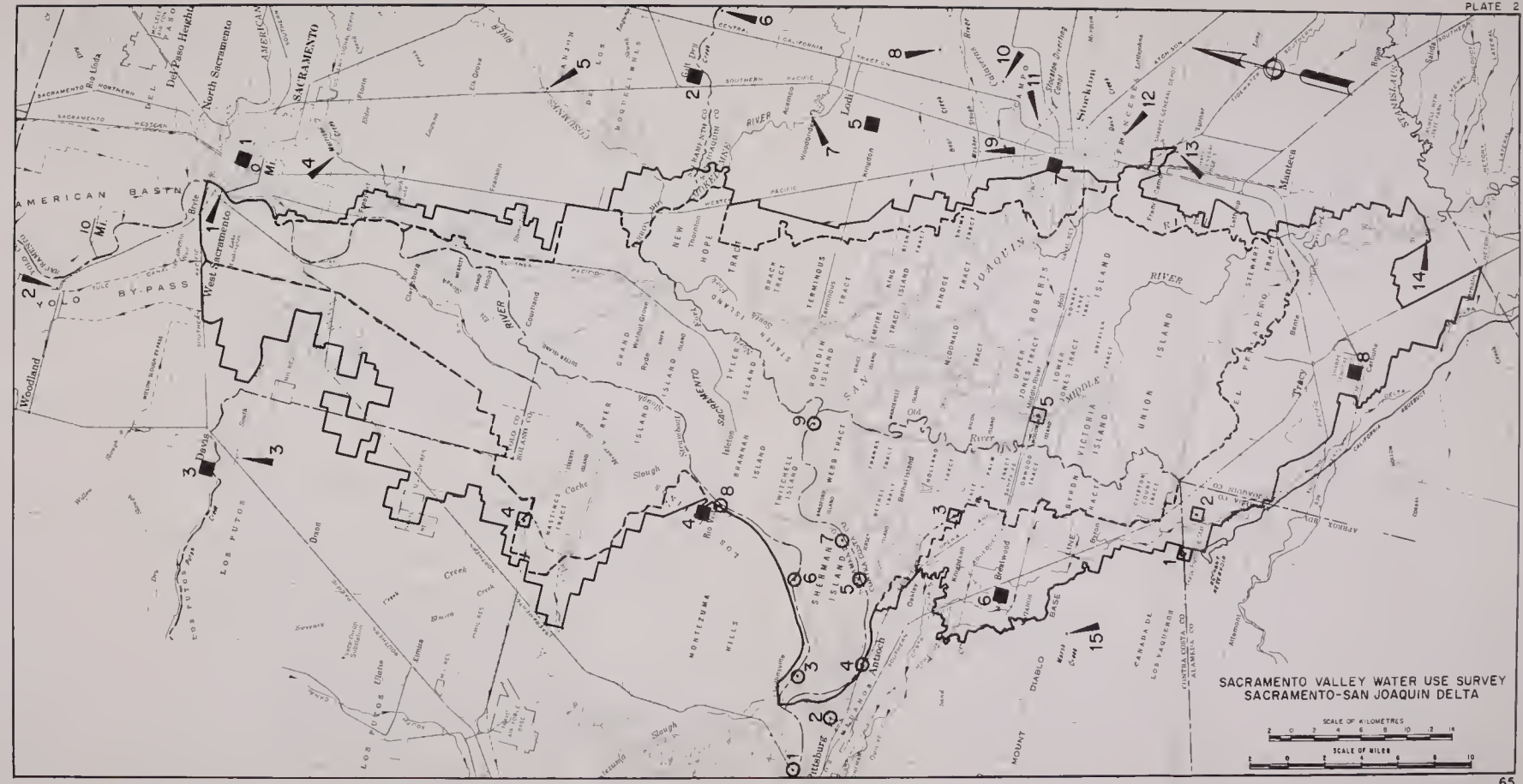
1 Sacramento River, Chipps Island
2 Sacramento River, Pittsburg
3 Sacramento River, Collinsville
4 San Joaquin River at Antioch
5 San Joaquin River at Blind Point
6 Sacramento River at Emmaton
7 San Joaquin River at Jersey Point
8 Sacramento River below Rio Vista
9 San Joaquin River at San Andreas

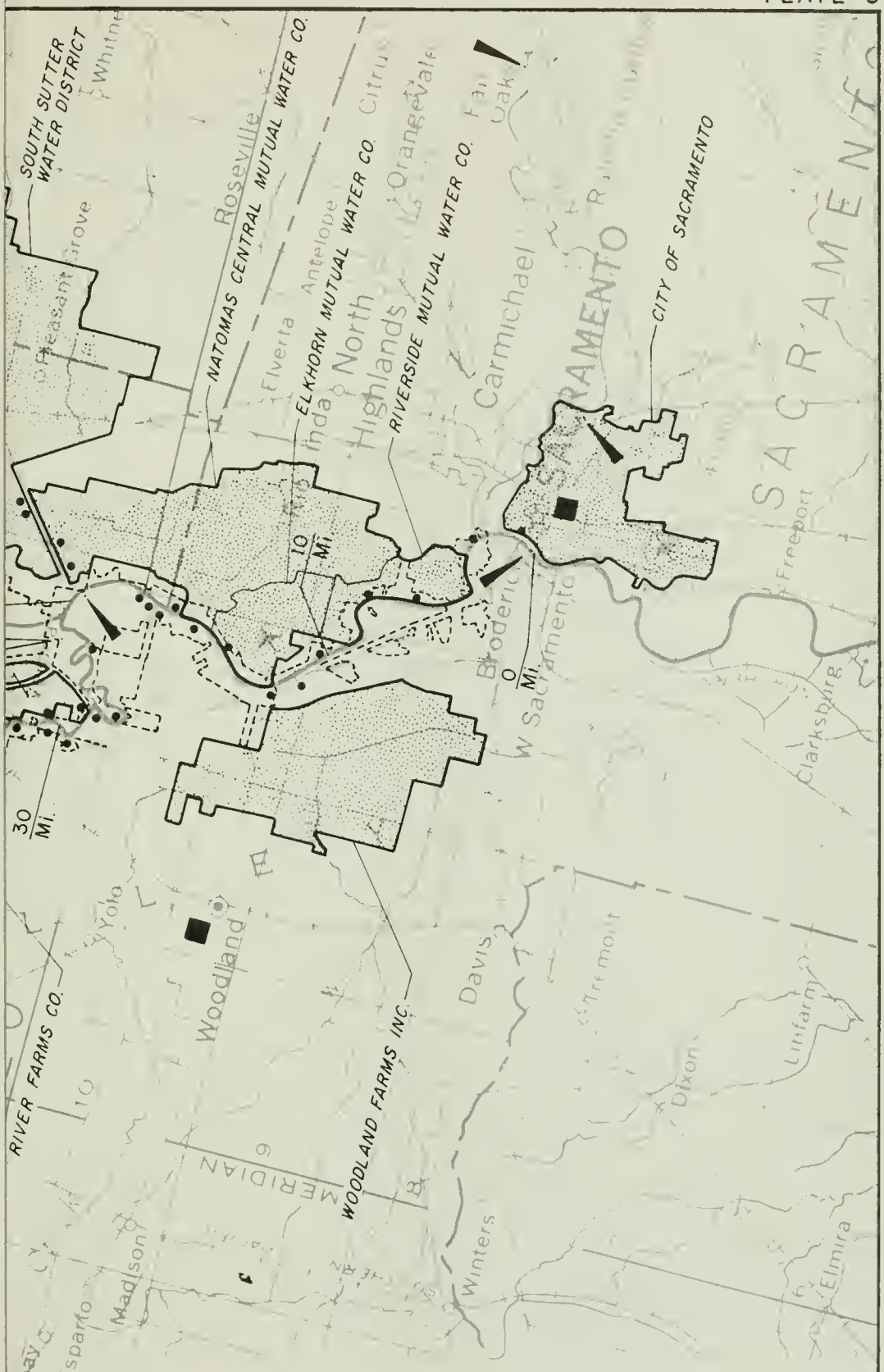
EXPORT LOCATIONS

1 California Aqueduct
2 Delta Mendota Canal
3 Contra Costa Canal
4 City of Vallejo
5 East Bay Municipal Utility District

PRECIPITATION MEASURING STATIONS

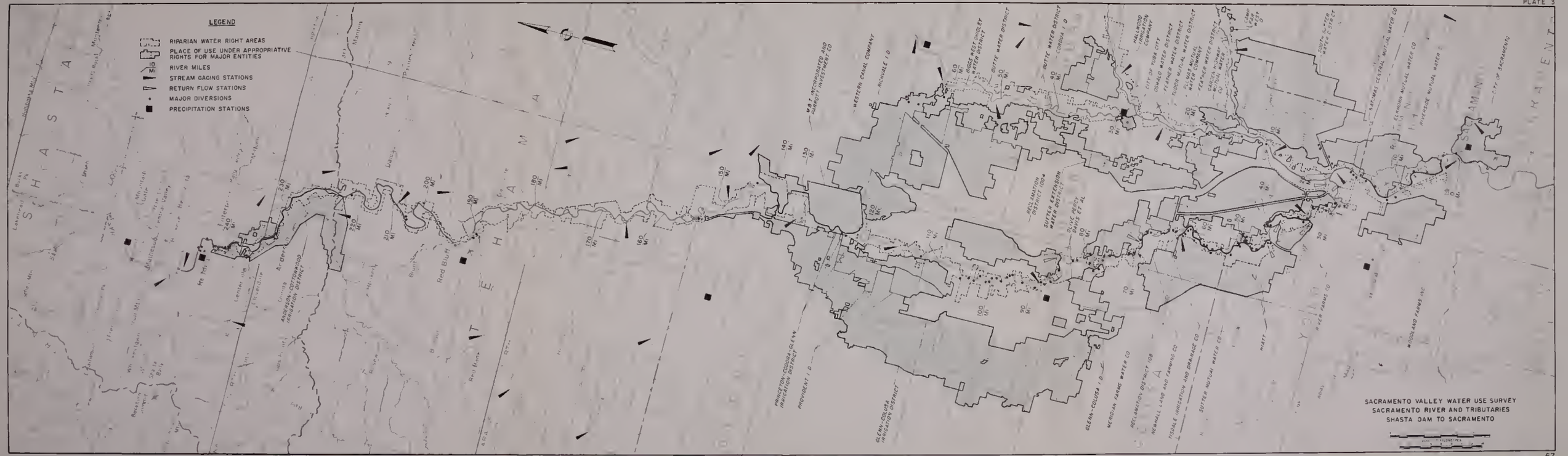
1 Sacramento
2 Galt
3 Davis
4 Rio Vista
5 Lodi
6 Brentwood Corporation Yard
7 Stockton
8 Tracy



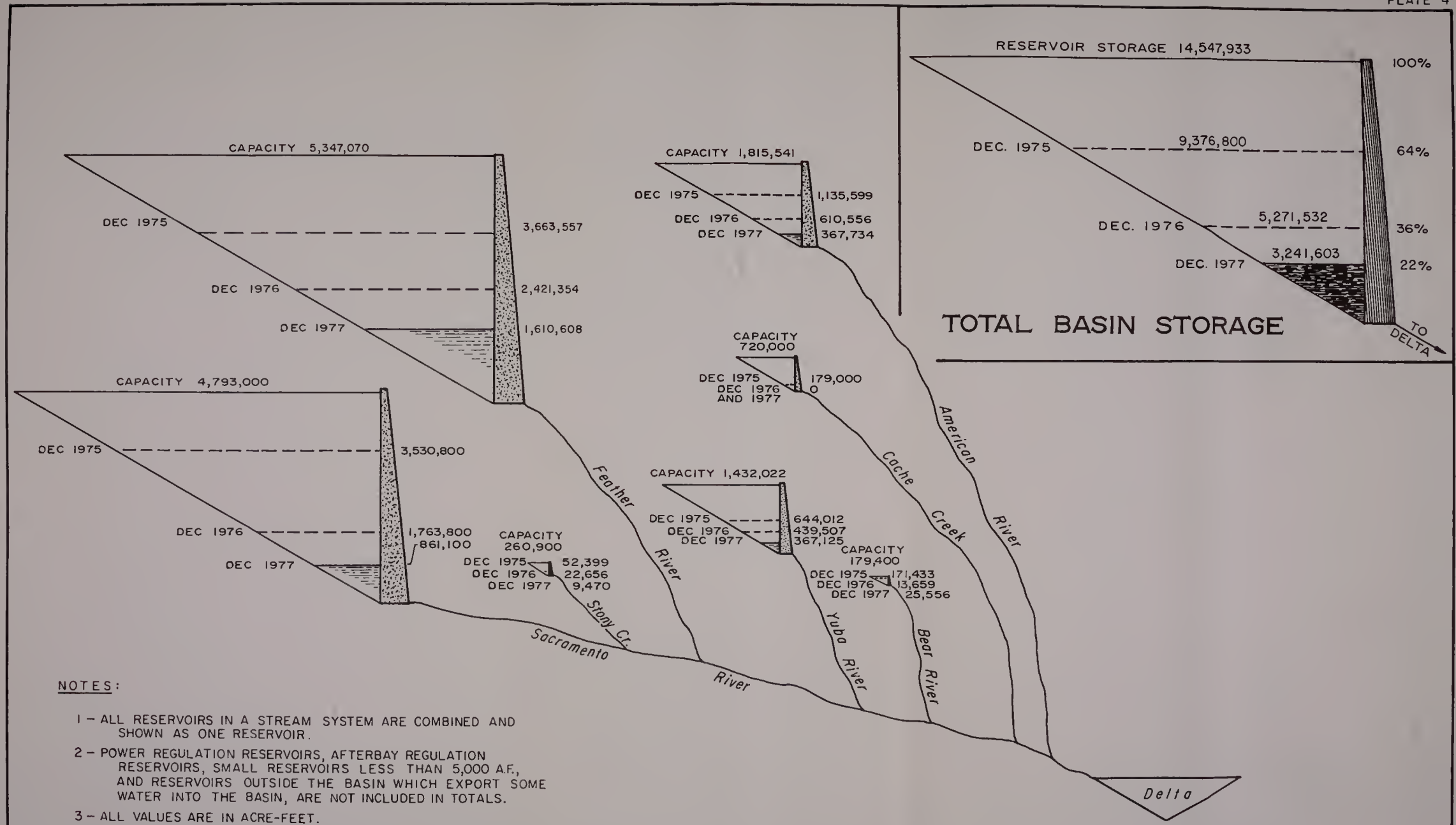


SACRAMENTO VALLEY WATER USE SURVEY
SACRAMENTO RIVER AND TRIBUTARIES
SHASTA DAM TO SACRAMENTO

SCALE OF MILES
2 0 2 4 6 8 10
SCALE OF KILOMETRES
2 0 2 4 6 8 10 12 14



SACRAMENTO VALLEY WATER USE SURVEY
SACRAMENTO RIVER AND TRIBUTARIES
SHASTA DAM TO SACRAMENTO



NOTES:

1 – ALL RESERVOIRS IN A STREAM SYSTEM ARE COMBINED AND SHOWN AS ONE RESERVOIR.

2 – POWER REGULATION RESERVOIRS, AFTERBAY REGULATION RESERVOIRS, SMALL RESERVOIRS LESS THAN 5,000 A.F., AND RESERVOIRS OUTSIDE THE BASIN WHICH EXPORT SOME WATER INTO THE BASIN, ARE NOT INCLUDED IN TOTALS.

3 – ALL VALUES ARE IN ACRE-FEET.

4 – VALUES ARE FOR FIRST DAY OF DECEMBER.

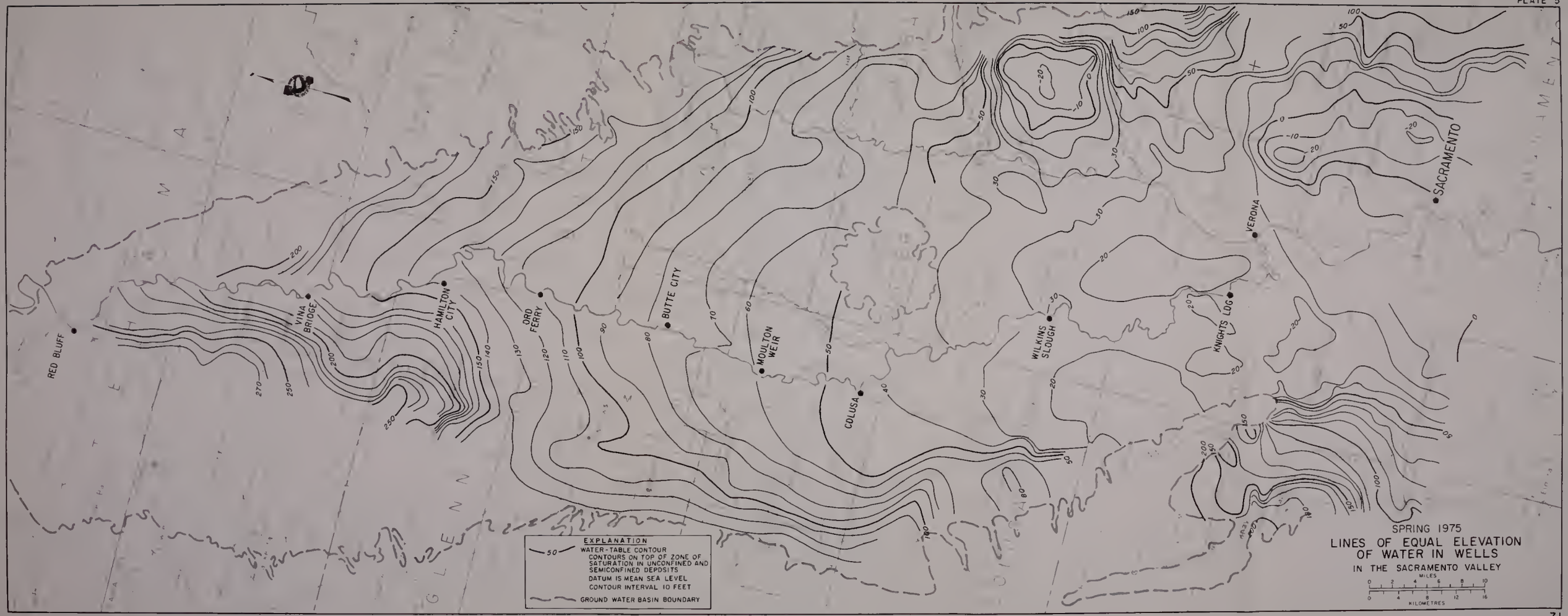
5 – METRIC CONVERSION: ACRE-FEET TIMES 1233.5 EQUALS CUBIC METRES.

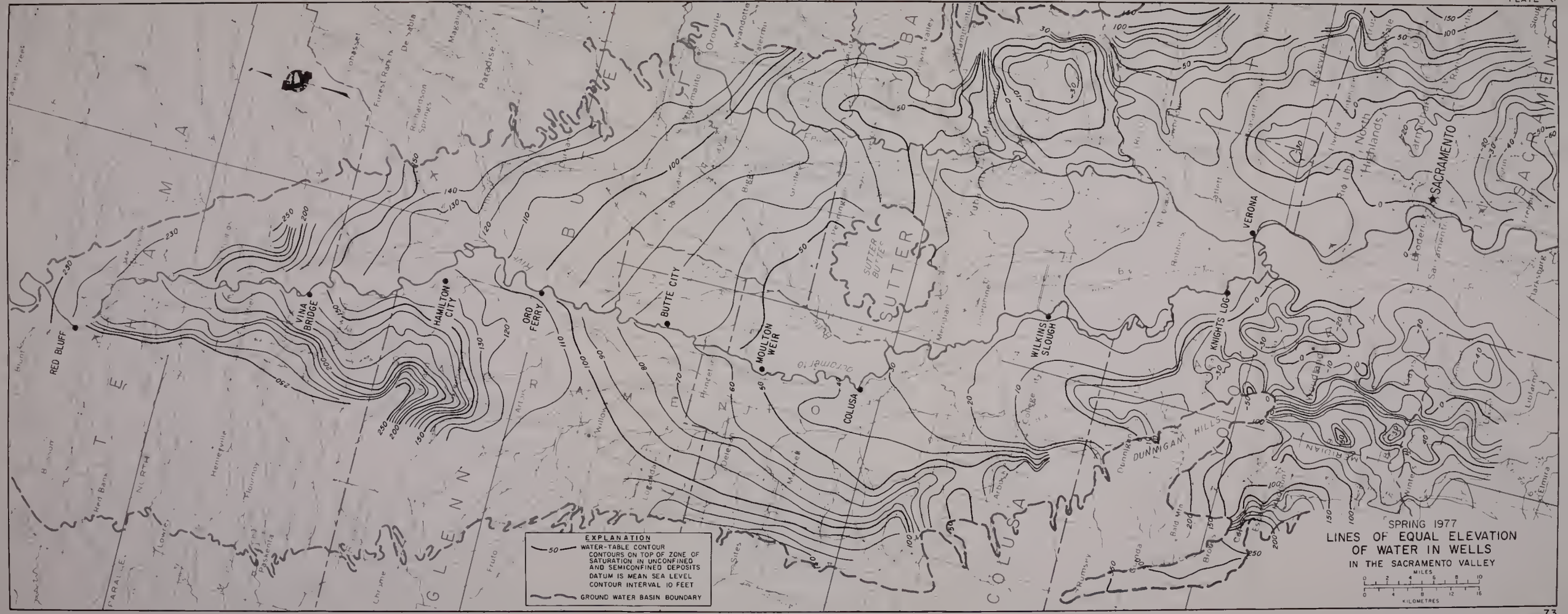
6 – INCLUDES UNUSABLE WATER IN DEAD STORAGE

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

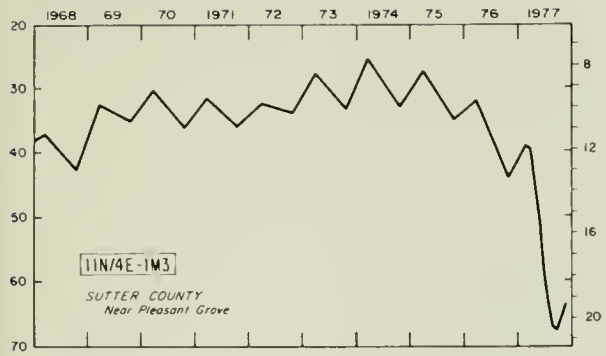
SACRAMENTO VALLEY WATER USE SURVEY

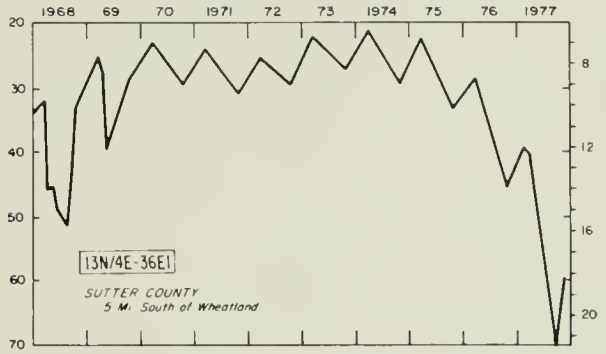
SACRAMENTO BASIN RESERVOIR STORAGE DECEMBER 1975, 1976, AND 1977

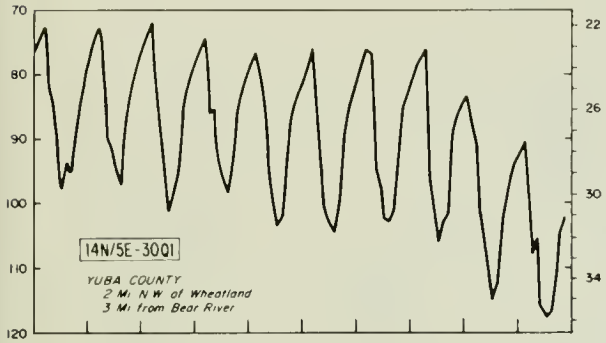

RED BLUFF
VINA BRIDGE
HAMILTON CITY
ORD FERRY
BUTTE CITY
MOULTON WEIR
COLUSA
WILKINS SLOUGH
KNIGHTS LOG
VERONA
SACRAMENTO
EXPLANATION
50
WATER-TABLE CONTOUR
CONTOURS ON TOP OF ZONE OF SATURATION IN UNCONFINED AND SEMICONFINED DEPOSITS
DATUM IS MEAN SEA LEVEL
CONTOUR INTERVAL 10 FEET
GROUND WATER BASIN BOUNDARY
SPRING 1975
LINES OF EQUAL ELEVATION OF WATER IN WELLS
IN THE SACRAMENTO VALLEY
MILES
KILOMETRES

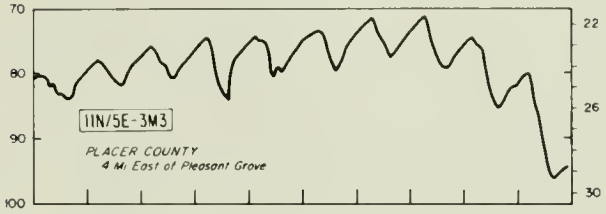

RED BLUFF
VINA BRIDGE
HAMILTON CITY
ORD FERRY
BUTTE CITY
MOULTON WEIR
COLUSA
WILKINS SLOUGH
KNIGHTS LDG.
VERONA
SACRAMENTO
TEHAMA
GLENN
BUTTE
SUTTER
YUBA
COLUSA
SACRAMENTO
DUNNIGAN HILLS
EXPLANATION
50 WATER-TABLE CONTOUR
CONTOURS ON TOP OF ZONE OF SATURATION IN UNCONFINED AND SEMICONFINED DEPOSITS
DATUM IS MEAN SEA LEVEL
CONTOUR INTERVAL 10 FEET
GROUND WATER BASIN BOUNDARY
SPRING 1977
LINES OF EQUAL ELEVATION OF WATER IN WELLS
IN THE SACRAMENTO VALLEY
MILES
KILOMETRES

RED BLUFF
VINA BRIDGE
HAMILTON CITY
ORD FERRY
BUTTE CITY
MOULTON WEIR
COLUSA
WILKINS SLOUGH
KNIGHTS LOG
VERONA
SACRAMENTO
TEHAMA
GLENN
BUTTE
SUTTER
YUBA
COLUSA
YOLO
SACRAMENTO
NORTH
PARALLEL
SUTTER BUTTES
DUNNIGAN HILLS
EXPLANATION
-10 CONTOUR SHOWING CHANGE IN WATER-TABLE
CONTOUR INTERVAL 5 FEET
SEE PLATES FOR WATER TABLE CONTOURS OF SPRING 1975 AND 1977
GROUND WATER BASIN BOUNDARY
SPRING 1975 TO SPRING 1977
LINES OF EQUAL CHANGE IN ELEVATION OF WATER IN WELLS
IN THE SACRAMENTO VALLEY
MILES
KILOMETRES



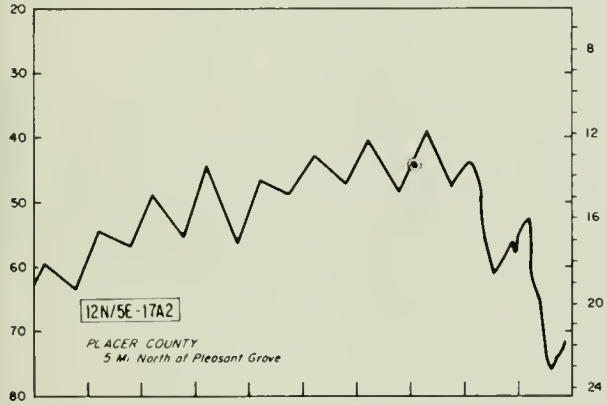


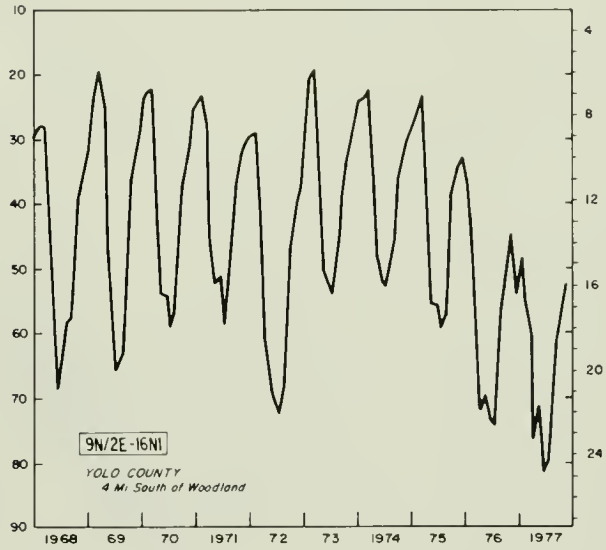


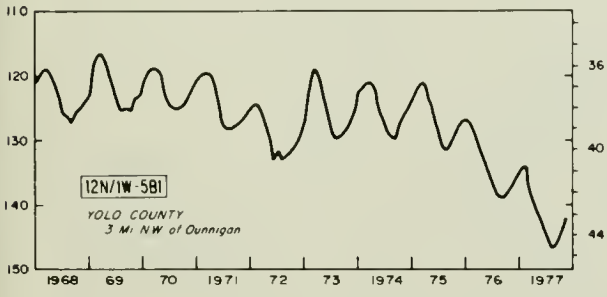


DEPTH TO WATER IN FEET

DEPTH TO WATER IN METRES





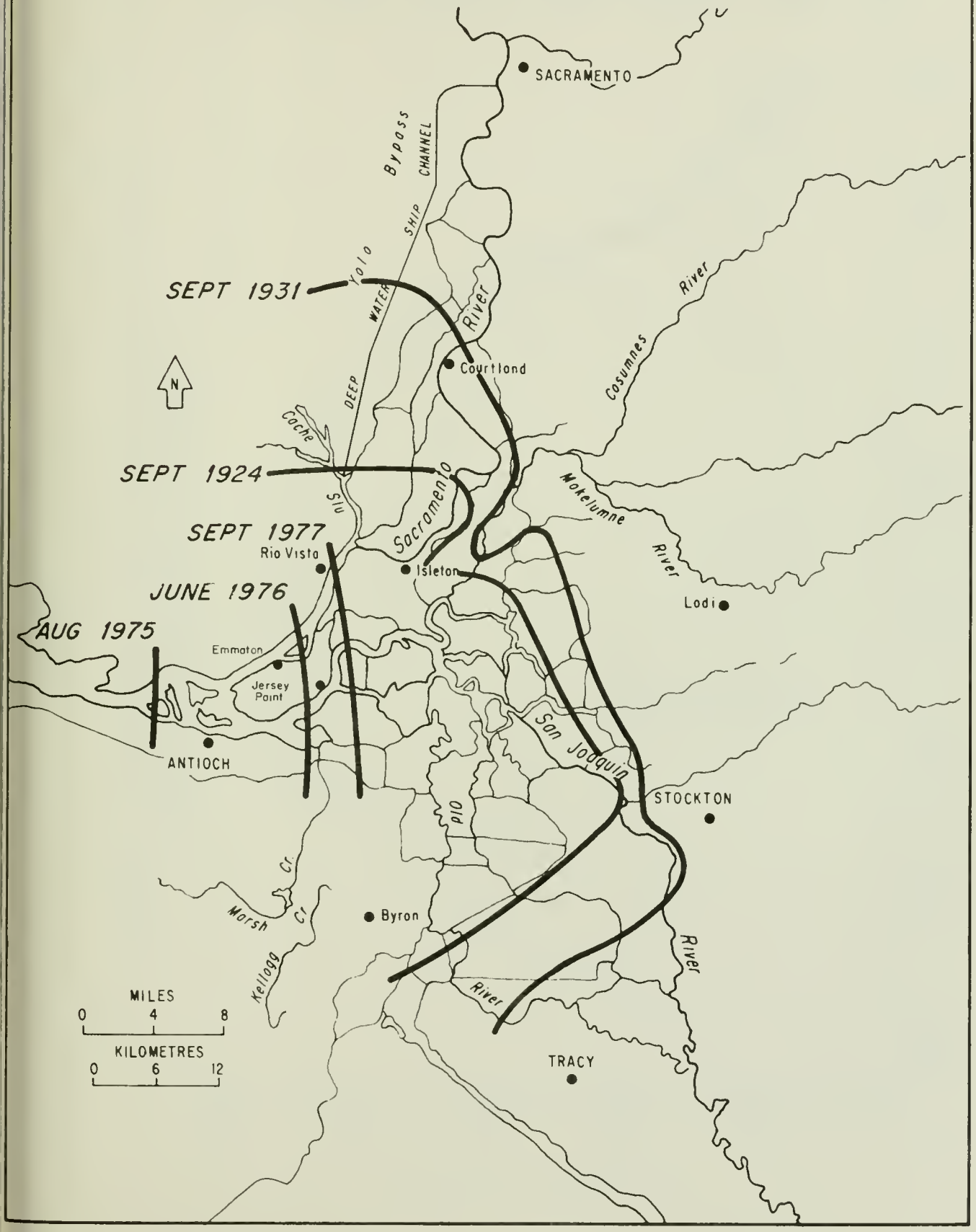


HYDROGRAPHS OF DEPTHS TO WATER IN WELLS IN SACRAMENTO VALLEY 1968 TO 1977

SACRAMENTO VALLEY WATER USE SURVEY

DELTA SALINITY ENCROACHMENT FOR YEARS 1924, 1931, 1975, 1976, & 1977

1000 MILLIGRAMS PER LITRE CHLORIDES



MONTHLY DIVERSIONS FROM SACRAMENTO RIVER ABOVE SACRAMENTO (1972-1977)

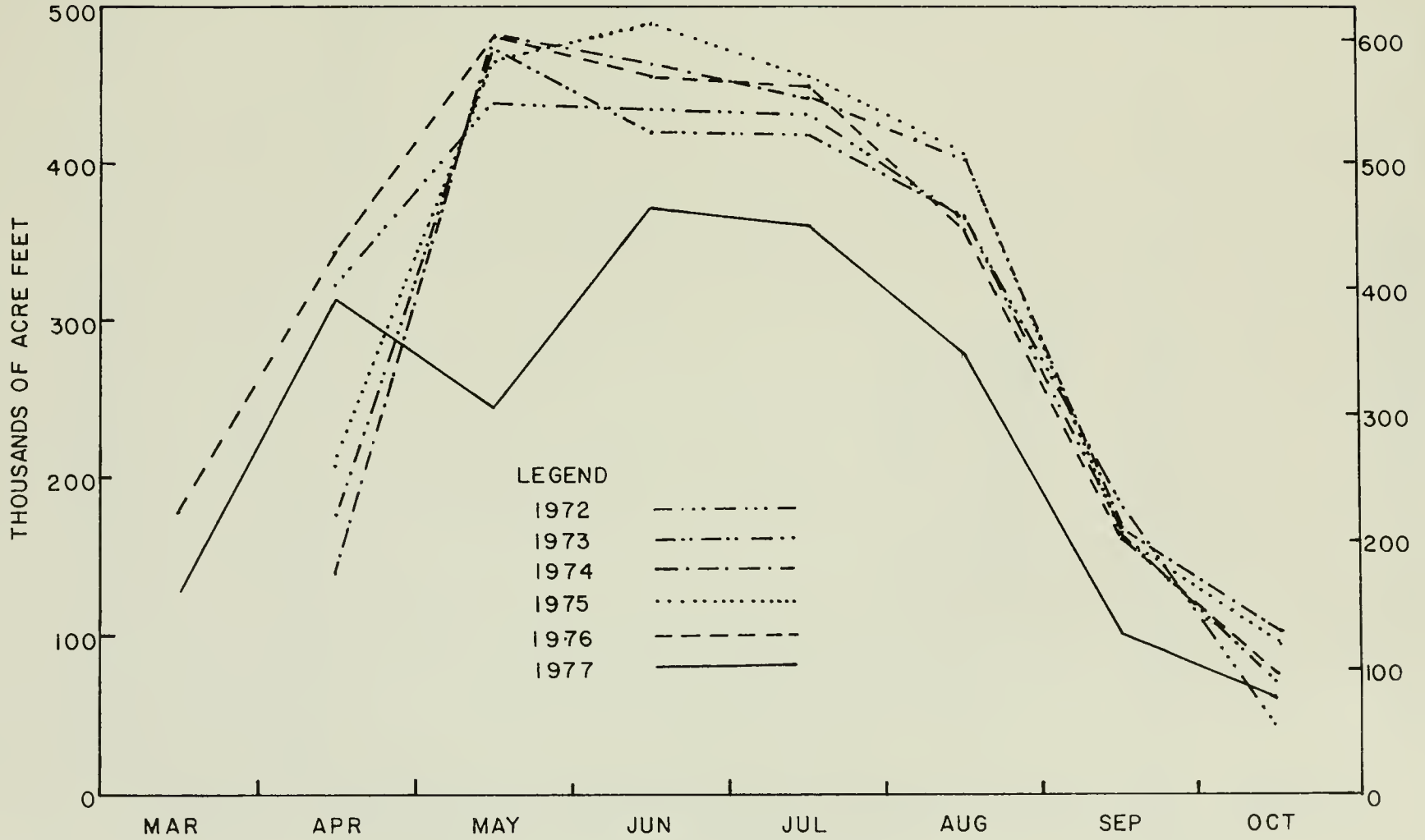
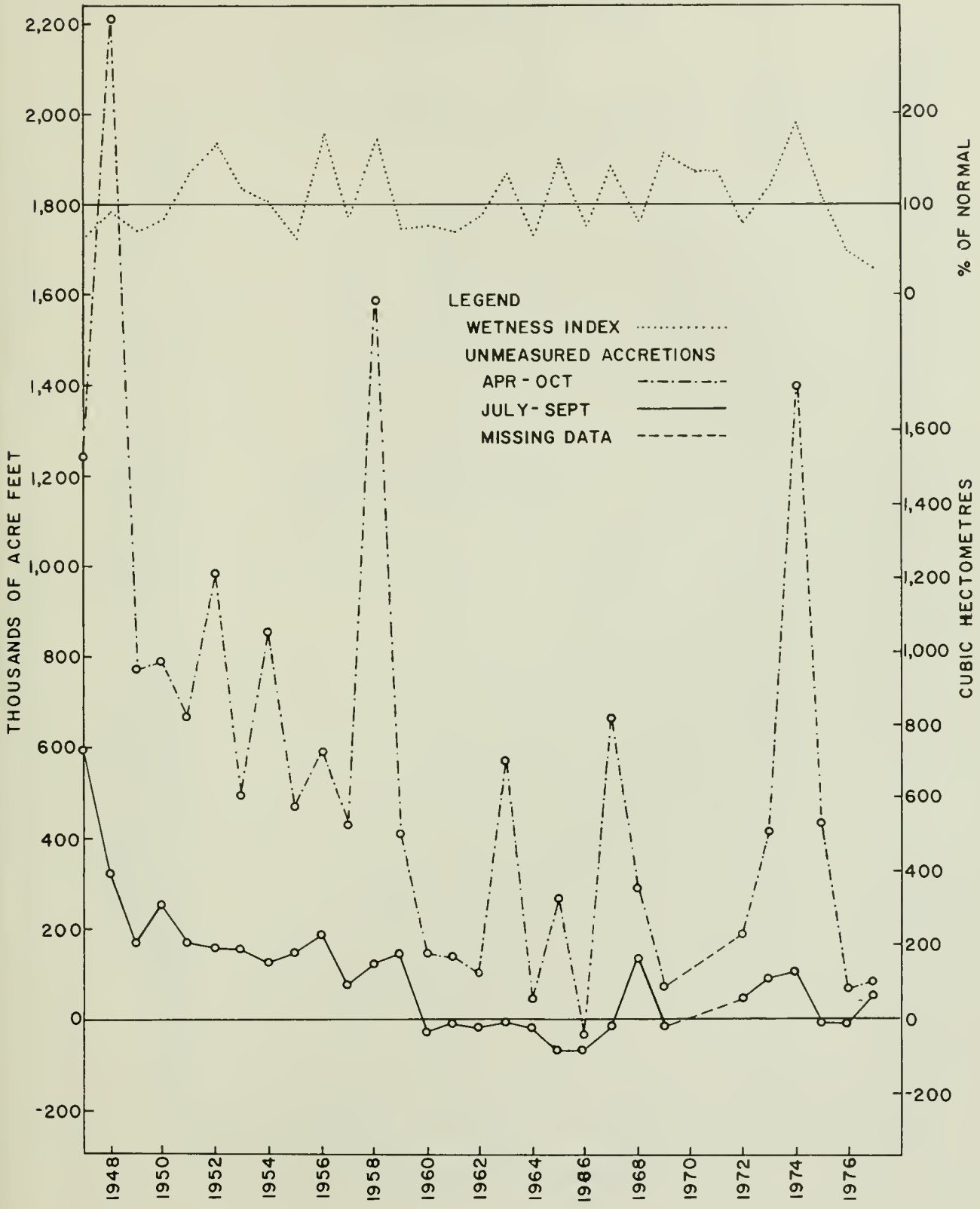
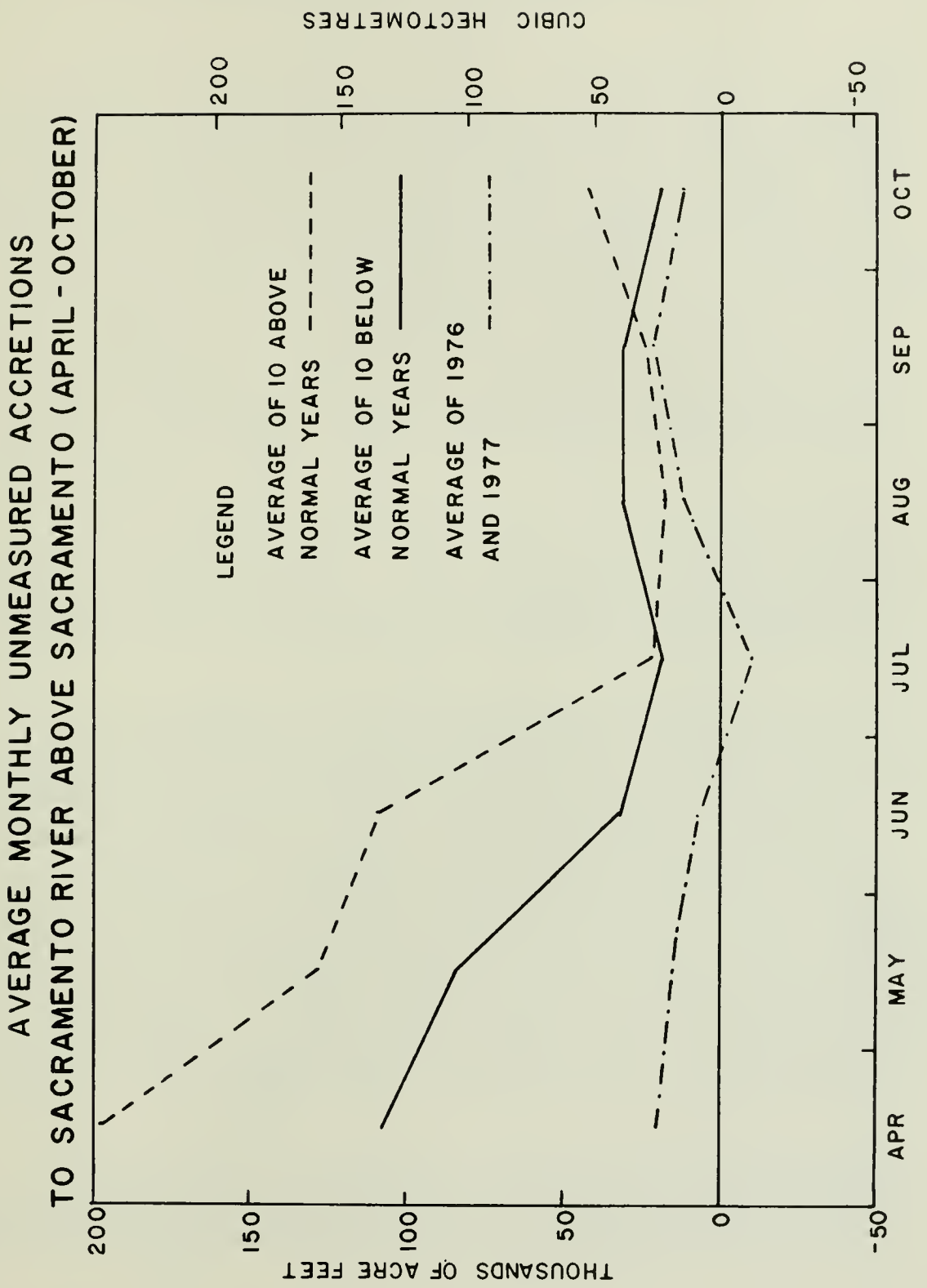


PLATE 10

SEASONAL UNMEASURED ACCRETIONS TO SACRAMENTO RIVER ABOVE SACRAMENTO




AVERAGE MONTHLY UNMEASURED ACCRETIONS
TO SACRAMENTO RIVER ABOVE SACRAMENTO (APRIL - OCTOBER)
LEGEND
AVERAGE OF 10 ABOVE NORMAL YEARS
AVERAGE OF 10 BELOW NORMAL YEARS
AVERAGE OF 1976 AND 1977
THOUSANDS OF ACRE FEET
200
150
100
50
0
-50
CUBIC HECTOMETRES
200
150
100
50
0
-50
APR
MAY
JUN
JUL
AUG
SEP
OCT

APPENDIX

ESTIMATE OF EVAPOTRANSPIRATION (ET) FOR THE DELTA - 1976-1977

Climatic conditions affecting evapotranspiration in the Delta area were reviewed for the period, October 1976 to October 1977. Evaporation was substantially higher during the months of March and April and lower in May in comparison to a normal year's evaporation, as illustrated by Figure A-1. Although the pattern of evaporation of the Class A pans for the months of March and April in the Delta area were unusual, in checking evaporation for many stations in the Central Valley from Red Bluff to Bakersfield, the same pattern consistently prevailed. Similar evaporation patterns were observed for other stations along the coast and in Southern California as well. This phenomenon is illustrated by Figure A-2, showing the similarity in the pattern of evaporation among the Davis Hydromet, Gerber 1SW, Shafter Cotton Station, and DWR Wasco 8SW Class A pans. Their similarity substantiates that the pattern of evaporation reflects the actual climatic conditions in the Delta.

Even though the 1976-1977 pattern of the monthly pan evaporation varied from that of the normal years, the annual rate was only slightly higher. This and other climatic factors that influence water consumption were analyzed to determine the evapotranspiration rates of various crops and other land-use categories.

The measurements of the evapotranspiration rates for grass (PET) by a lysimeter method at UC-Davis, the basis for establishing the 1975-76 evapotranspiration of various crops (ET), were terminated in September 1976. Furthermore, measurements at the Davis Weather Station (2WSW) for the current year lacked 2 months of pan evaporation and the validity of several months' were also in question. Therefore, it was not possible to evaluate the current year's water use of the Delta precisely on the same basis that the 1975-76 water use was determined. The method finally adopted, after investigating various alternatives, involved the calculation of coefficients (Kp) for three Class A pans by taking into account the ground cover, mean relative humidity, and 24-hour wind movement. The procedures used are prescribed in the FAO Irrigation and Drainage Paper 24, "Crop Water Requirements", Food and Agriculture Organization (FAO) of the United Nations, by J. Doorenbos, W. O. Pruitt, et al.

The three above mentioned Class A pans have been maintained for several years. These pans, located at Lodi, Brannan Island, and Antioch Pumping Plant, are each exposed to varying environmental conditions that influence the evaporation rates.

FIGURE A-1

DRY LAND ENVIRONMENT
1976 - 1977 EVAPORATION
CLASS A PAN

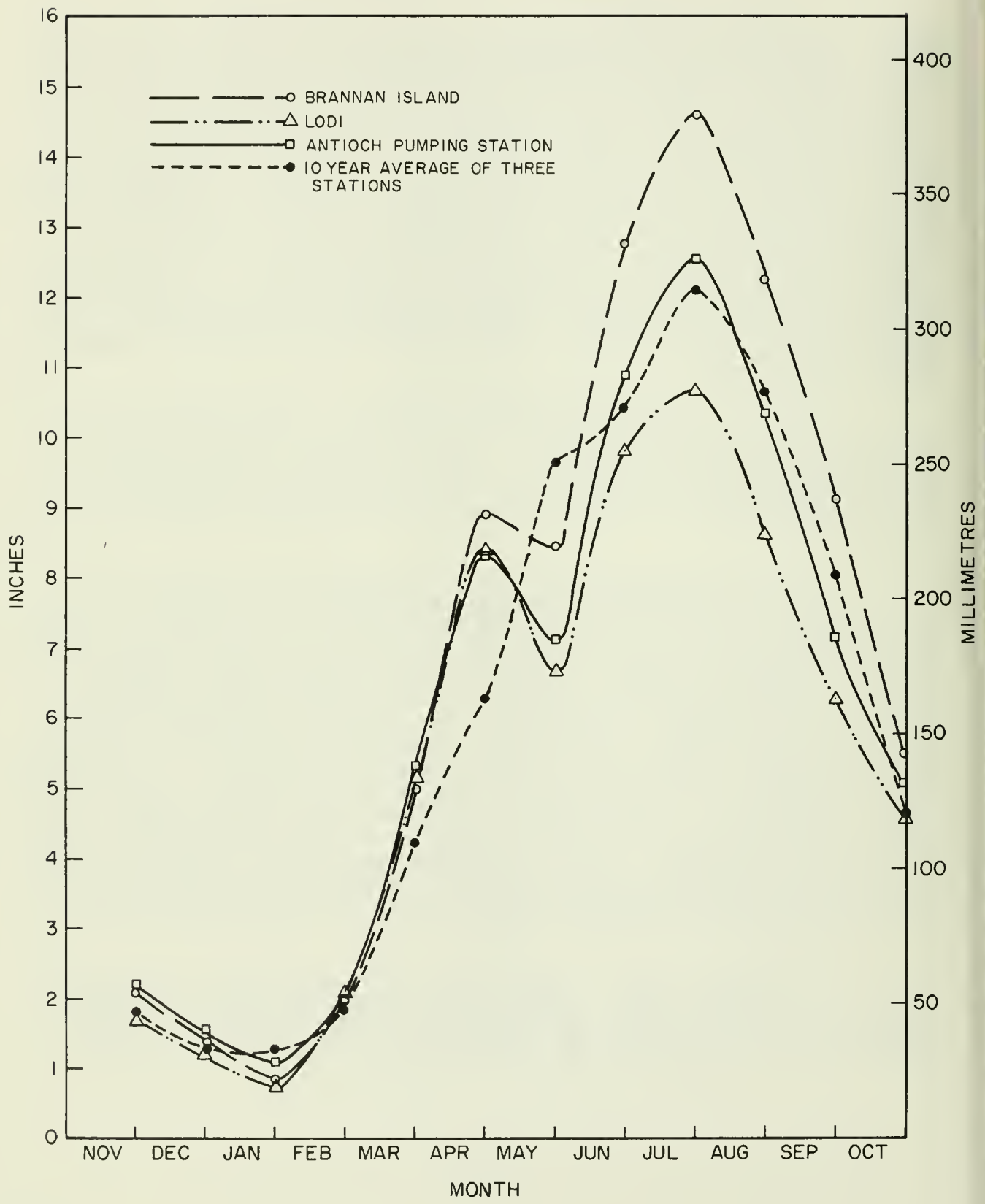
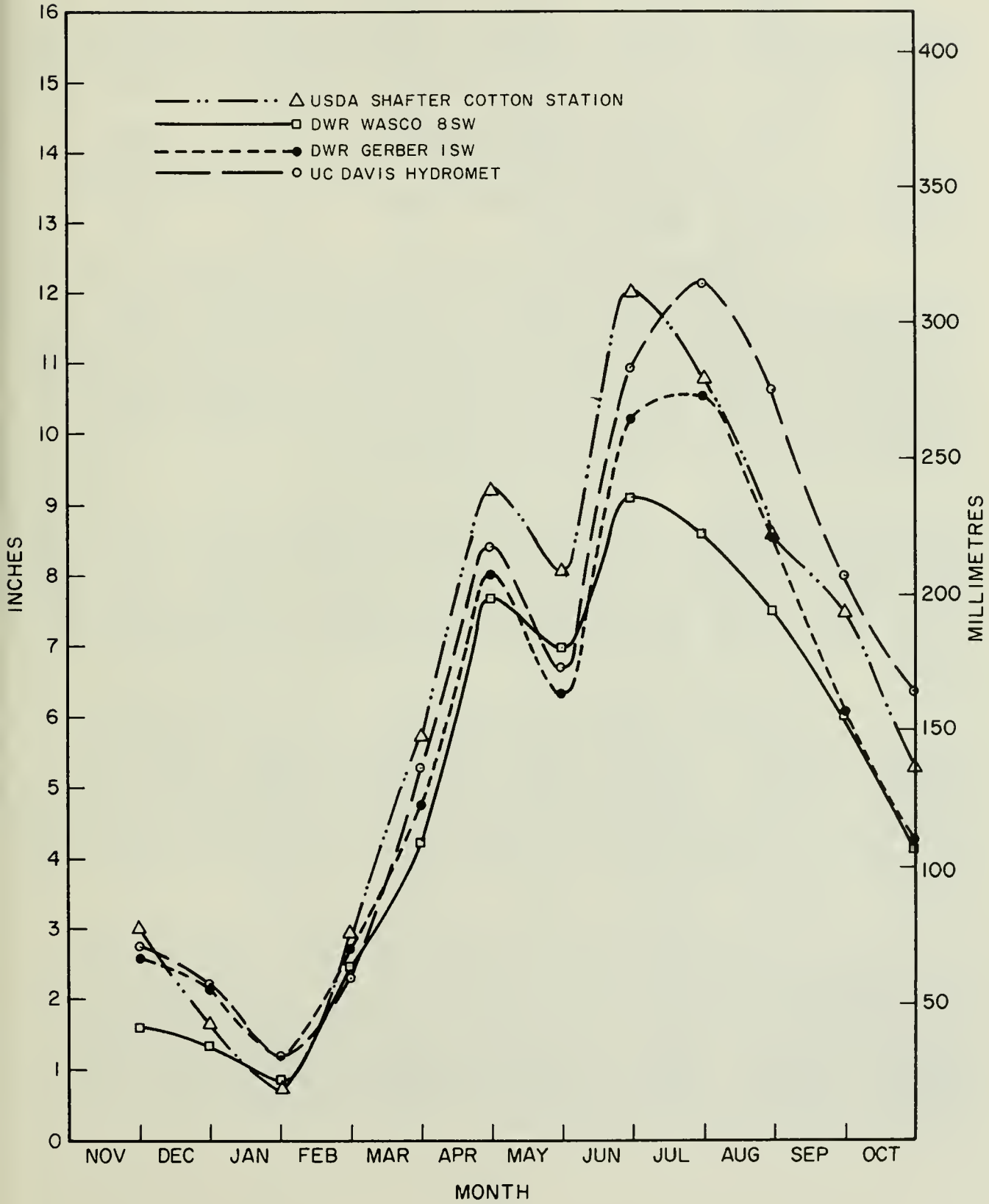


FIGURE A-2

1976 - 1977 EVAPORATION
CLASS A PAN



These variations largely account for the differences in the evaporation rates among them. The monthly evaporation rates from these pans as well as at Davis Hydromet and Davis Weather Station 2WSW are presented in Table A-1. It shows the comparison of the 1975-76, 1976-77, and the 10-year average evaporation rates.

As of May 1, 1977, the pan at Lodi was relocated. The new location of the pan is adjacent to a large irrigated park from which the wind generally prevails. For this reason, Lodi has the lowest evaporation rate of the three pans, during the 1976-77 year.

The level of relative humidity for the three Class A pans in the Delta was based on measurements made at Stockton Airport. The temperature records show little differences among the pan locations, so it was assumed that the relative humidity would likewise be similar.

Wind movements were measured at Lodi and Brannan Island. The Class A pan at Antioch Pumping Plant is located within an almond orchard and it was assumed that wind movement at this station would be much less than that of Brannan Island. The records of wind movement at the Dow Chemical Company at Pittsburg during 1956-65, indicate the prevailing wind is usually from the west and west-northwest directions. This is illustrated by Table A-2, which shows the prevailing wind direction as well as the mean speed at Stockton, Travis AFB, and Sacramento.

Table A-3 shows the factors and values used in deriving the pan coefficients (Kp) and the resulting PET's for each of the three pan locations and for the Delta as a whole. The PET's are the result of taking the product of Ep and Kp values. The noted distance of fetch is the extent of dry land surrounding the pan which is measured toward the prevailing wind from the pan to a green crop, water surface, irrigated land area, or naturally wet area.

Table A-4 shows the comparison of the 1976-77 PET's to those reported in the 1975-76 "Sacramento Valley Water Use Survey" report. The latter PET values were based on more than 10 years of data. The table also shows the percentage differences between the two, which provided the basis for computing the 1976-77 crop unit ET values shown in Table A-5. The ET values shown are the result of adjusting the corresponding long-term ET by the indicated percentage changes.

The growing season for the same annual crops may vary according to the planting and harvesting dates. Therefore, the monthly evapotranspiration for those crops is an integration of the different planting and harvesting dates. This is illustrated in Table A-6. It shows the normal ET of the same crops planted and harvested at various dates along with the composite 1976-77 monthly values. The latter includes the ET rates for the nonirrigation season as well. These are the same values shown for the corresponding crops in Table A-5.

TABLE A-1

Evaporation - Class A Pans
From October 1975 thru October 1977
(In Inches)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Total	: Oct. 1977
Delta Area														
Antioch Pumping Plant (Dry Land Environment)														
10-Year Avg.	4.86	1.76	1.42	1.26	1.88	4.15	6.35	9.22	10.54	11.48	10.00	7.85	70.77	
1975-76	4.32	2.53	1.45	1.53	1.85	4.93	6.45	10.65	11.78	12.27	8.46	7.23	73.45	
1976-77	4.70	2.18	1.56	1.06	2.16	5.33	8.34	7.12	10.89	12.76	10.35	7.18	73.63	5.12
Brannan Island (Dry Land Environment)														
7-Year Avg.	4.84	1.78	1.07	1.17	1.59	4.22	6.65	10.49	11.90	13.70	12.36	8.94	78.71	
1975-76	4.41	2.12	0.97	1.45	1.90	4.78	6.72	11.90	13.07	14.42	9.52	7.90	79.16	
1976-77	5.01	2.09	1.33	0.80	1.98	4.99	8.92	8.46	12.78	14.62	12.27	9.14	82.39	5.52
Lodi (Dry Land Environment)														
10-Year Avg.	4.43	1.87	1.31	1.37	2.01	4.31	5.92	9.22	10.43	11.23	9.71	7.41	69.22	
1975-76	3.91	2.07	1.11	1.11	2.12	4.85	7.00	10.76	12.16	11.68	8.02	7.24	72.03	
1976-77	4.90	1.68	1.19	0.75	2.10	5.16	8.40	6.70	9.83	10.72	8.63	6.30	66.36	4.59
Average of Above Three Stations (Dry Land Environment)														
10-Year Avg.	4.71	1.80	1.27	1.27	1.83	4.23	6.31	9.64	10.33	12.14	10.69	8.07	72.29	
1975-76	4.21	2.26	1.18	1.36	1.96	4.85	6.72	11.10	12.34	12.79	8.67	7.46	74.90	
1976-77	4.87	1.98	1.36	0.87	2.08	5.16	8.55	7.43	11.17	12.70	10.42	7.54	74.13	5.08
Davis Hydromet (Irrigated Pasture Environment)														
10-Year Avg.	5.27	2.15	1.38	1.56	2.13	4.45	6.83	8.93	9.94	10.27	9.31	7.75	69.97	
1975-76	4.91	3.47	1.62	2.53	2.99	5.87	7.27	11.64	13.58	11.46	8.15	6.85	80.34	
1976-77	6.34	2.75	2.21	1.18	2.29	5.25	8.38	6.69	10.93	12.09	10.62	7.99	76.72	
Davis 2 WSW (Dry Land Environment)														
10-Year Avg.	6.48	2.46	1.43	1.68	2.23	4.70	7.77	10.99	12.52	13.24	11.67	9.43	84.60	
1975-76	5.31	3.91	1.86	2.81	2.73	6.03	7.49	12.94	15.05	13.22	9.63	8.02	89.00	
1976-77	6.64	NA	NA	NA	2.50	5.95	9.69	7.49	12.63	13.07	11.37	8.69		

Metric conversion: inches times 25.4 equals millimetres.

TABLE A-2

Wind Movement

Month	Prevailing Direction				Mean Speed M.P.H.		
	1/ Pittsburg 1956-65	2/ Sacramento 1941-63	2/ Stockton 1941-63	2/ Travis AFB 1943-72	2/ Sacramento	2/ Stockton	2/ Travis AFB
Jan.	SE	SE	SE	N	7.8	6.7	7
Feb.	W	SSE	SE	SW	7.9	7.0	8
Mar.	W	SW	W	SW	9.0	7.6	9
Apr.	W	SW	W	SW	9.1	8.2	11
May	W	SW	W	SW	9.4	9.1	13
June	W	SW	W	SW	10.0	9.1	15
July	WNW	SSW	WNW	SW	9.2	8.2	17
Aug.	WNW	SW	WNW	SW	8.7	7.6	15
Sep.	WNW	SW	W	SW	7.8	7.0	13
Oct.	WNW	SW	W	SW	6.8	6.3	9
Nov.	W	NNW	W	SW	6.4	5.7	6
Dec.	ESE	SSE	SE	N	7.1	6.2	6
Annual	WNW	SW	W	SW	8.3	7.4	9

1/ DWR Memorandum Report: Wind of California by James Goodridge

2/ Climates of California, National Climatic Center, Ashville, N.C.

Metric conversion: M.P.H. times 1.61 equals kilometres per hour.

TABLE A-3
Estimation of Potential Evapotranspiration (PET)
Based on Class A Pan Evaporations 1/
1975-76 and 1976-77
(in inches)

Antioch Fetch 50m						Brannan Island Fetch 100m					
Month	Ep 2/	RH 3/	Wind 4/	Kp	PET	Month	Ep 2/	RH 3/	Wind 4/	Kp	PET
1975-76											
Oct. 75	4.32	M+	L	.70	3.02	Oct. 75	4.41	M+	L+	.66	2.91
Nov.	2.53	M+	L	.71	1.80	Nov.	2.12	M+	L	.67	1.42
Dec.	1.45	H	L	.76	1.10	Dec.	.97	H	L	.75	.73
Jan. 76	1.53	M+	L	.71	1.09	Jan. 76	1.45	M+	L	.67	.97
Feb.	1.85	H-	L	.73	1.35	Feb.	1.90	H-	L	.71	1.35
Mar.	4.93	M+	L	.69	3.40	Mar.	4.78	M+	L+	.66	3.15
Apr.	6.45	M+	L	.69	4.45	Apr.	6.72	M+	L+	.66	4.44
May	10.65	M	L	.67	7.14	May	11.90	M	M	.60	7.14
June	11.78	M-	L	.63	7.42	June	13.07	M-	M	.56	7.32
July	12.27	M-	L	.64	7.85	July	14.42	M-	M	.57	8.22
Aug.	8.46	M-	L	.65	5.50	Aug.	9.52	M-	M	.58	5.52
Sep.	7.23	M	L	.67	4.84	Sep.	7.90	M	M	.60	4.74
1976-77											
Oct. 76	4.7	M	L	.67	3.15	Oct. 76	5.0	M	L	.65	3.25
Nov.	2.2	H-	L	.73	1.61	Nov.	2.1	H-	L	.71	1.49
Dec.	1.6	M+	L	.70	1.12	Dec.	1.3	M+	L	.68	.88
Jan. 77	1.1	H	L	.77	.85	Jan. 77	0.8	H	L	.75	.60
Feb.	2.2	H-	L	.73	1.61	Feb.	2.0	H-	L	.71	1.42
Mar.	5.3	M+	L	.70	3.71	Mar.	5.0	M+	L	.68	3.40
Apr.	8.3	M-	L	.64	5.31	Apr.	8.9	M-	L	.62	5.52
May	7.1	M	L	.67	4.76	May	8.5	M-	M	.58	4.93
June	10.9	M-	L	.63	6.87	June	12.8	M-	M	.56	7.17
July	12.8	M-	L	.62	7.94	July	14.6	M-	M	.55	8.03
Aug.	10.4	M-	L	.63	6.55	Aug.	12.3	M-	M	.56	6.89
Sep.	7.2	M	L	.67	4.82	Sep.	9.1	M	L	.60	5.46
Oct. 77	5.1	M	L	.67	3.42	Oct. 77	5.5	M	L	.65	3.58

1/ Based on evaporation pan method - Table 19 FAO Irrigation and Drainage Paper #24, Guidelines for Predicting Water Requirements
2/ Ep - Class A Pan Evaporations
3/ RH - Relative Humidity - Stockton Airport Weather Station. RH conditions are noted as either Low (L), Medium (M), or High (H).
4/ Wind conditions are noted as either Low (L), Medium (M), or High (H).

Metric conversion: inches times 25.4 equals millimetres.

TABLE A-3
(Continued)

Lodi Fetch 50m					Average PET			
Month	Ep 2/	RH 3/	Wind 4/	Kp	PET	Month	Antioch	Brannan Island	Lodi	Avg. Total
				1975-76						
Oct. 75	3.91	M+	L	.70	2.74	Oct. 75	3.02	2.91	2.74	2.89
Nov.	2.07	M+	L	.71	1.47	Nov.	1.80	1.42	1.47	1.56
Dec.	1.11	H	L	.76	.84	Dec.	1.10	.73	.84	0.89
Jan. 76	1.11	M+	L	.71	.79	Jan. 76	1.09	.97	.79	0.95
Feb.	2.12	H-	L	.73	1.55	Feb.	1.35	1.35	1.55	1.42
Mar.	4.85	M+	L	.69	3.35	Mar.	3.40	3.15	3.35	3.30
Apr.	7.00	M+	L	.69	4.83	Apr.	4.45	4.44	4.83	4.57
May	10.76	M	L	.67	7.21	May	7.14	7.14	7.21	7.16
June	12.16	M-	L	.63	7.66	June	7.42	7.32	7.66	7.47
July	11.68	M-	L	.64	7.48	July	7.85	8.22	7.48	7.85
Aug.	8.02	M-	L	.65	5.21	Aug.	5.50	5.52	5.21	5.41
Sep.	7.24	M	L	.67	4.85	Sep.	4.84	4.74	4.85	4.81
				1976-77						
Oct. 76	4.9	M	L6.2mph	.67	3.28	Oct. 76	3.15	3.25	3.28	3.23
Nov.	1.7	H-	L5.2	.73	1.24	Nov.	1.61	1.49	1.24	1.45
Dec.	1.2	M+	L5.3	.70	.84	Dec.	1.12	.88	.84	.95
Jan. 77	0.8	H	L6.3	.77	.62	Jan. 77	.85	.60	.62	.68
Feb.	2.1	H-	L6.6	.73	1.53	Feb.	1.61	1.42	1.53	1.52
Mar.	5.2	M+	L9.9	.70	3.64	Mar.	3.71	3.40	3.64	3.58
Apr.	8.4	M-	L10.2	.64	5.38	Apr.	5.31	5.52	5.38	5.40
May 5/	6.7	M	L10.3	.70	4.69	May	4.76	4.93	4.69	4.79
June 5/	9.8	M-	L9.6	.67	6.57	June	6.87	7.17	6.57	6.87
July 5/	10.7	M-	L10.1	.66	7.06	July	7.94	8.03	7.06	7.68
Aug. 5/	8.6	M-	L9.5	.67	5.76	Aug.	6.55	6.89	5.76	6.40
Sep. 5/	6.3	M	L8.2	.70	4.41	Sep.	4.82	5.46	4.41	4.67
Oct.	4.6	M	L	.70	3.22	Oct.	3.42	3.58	3.22	3.41

1/ Ibid.
2/ Ibid.
3/ Ibid.
4/ Ibid.
5/ Lodi station relocated May 1, 1977, and fetch changed from 50m to 10m.

Metric conversion: inches times 25.4 equals millimetres.
M.P.H. times 1.61 equals kilometres per hour.

TABLE A-4

Comparison of 1976-77 PET with the Long Term PET
with the Difference Expressed in Percent

Months	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	1977 Oct.
1976-77 PET (inches)	3.2	1.5	1.0	0.7	1.5	3.6	5.4	4.8	6.9	7.7	6.4	4.7	3.4
Long Term PET (inches)	2.8	1.1	0.9	0.7	1.5	2.7	4.1	5.5	6.4	7.6	6.6	4.6	2.8
Percent Change*	+14	+36	+11	0	0	+33	+32	-13	+8	+1	-3	+2	2.1*

* These percentages generally apply to all crops during the irrigation season. The crop Et values for October were further modified to reflect low rainfall conditions experienced that month.

Metric conversion: inches times 25.4 equals millimetres.

TABLE A-5
1976-77 Estimated Crop Et Values
Delta Service Area
(in inches)

Land Use Category	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Total Oct.76-Sep.77	Oct.77	Total Nov.77-Oct.77
Sacramento-San Joaquin Delta															
Irrigated Pasture	3.2	1.5	1.0	0.7	1.5	3.6	5.4	4.8	6.9	7.7	6.4	4.7	47.4	3.4	47.6
Alfalfa	3.2	1.5	1.0	0.7	1.5	3.2	4.9	4.4	6.5	7.5	6.5	4.9	45.8	3.4	46.0
Deciduous Orchard (Fruits & Nuts)	2.6	1.5	1.0	0.7	1.5	2.7	3.8	4.0	6.1	7.4	6.1	4.3	41.7	2.6	41.7
Tomatoes	2.4	1.5	1.0	0.7	1.5	1.9	2.2	2.6	4.0	8.2	6.0	2.3	34.3	1.9	33.8
Sugar Beets	2.4	1.5	1.0	0.7	1.5	1.9	2.2	3.7	7.6	8.3	6.4	4.4	41.6	2.4	41.6
Grain Sorghum (Milo)	2.4	1.5	1.0	0.7	1.5	1.9	2.2	2.0	5.9	7.3	4.3	2.5	33.2	1.9	32.7
Field Corn	2.4	1.5	1.0	0.7	1.5	1.9	2.2	2.3	5.7	6.9	5.1	2.6	33.8	1.9	33.3
Dry Beans	2.4	1.5	1.0	0.7	1.5	1.9	2.2	1.7	5.7	6.2	2.7	2.5	30.0	1.9	29.5
Safflower	2.4	1.5	1.0	0.7	1.5	1.9	2.5	4.8	8.7	7.7	4.4	2.5	39.6	1.9	39.1
Asparagus	2.4	1.5	1.0	0.7	1.5	1.9	2,2	1.0	3.5	7.7	6.4	4.7	34.5	2.4	34.5
Potatoes	2.4	1.5	1.0	0.7	1.5	1.9	2.2	1.7	4.3	7.4	5.5	2.8	32.9	1.9	32.4
Irrigated Grain	2.4	1.5	1.0	0.7	2.0	4.3	5.7	3.1	1.8	1.0	1.0	1.6	26.1	1.6	24.7
Vineyard	2.4	1.5	1.0	0.7	1.5	1.9	2.2	2.8	5.3	6.5	5.3	3.4	34.5	2.4	34.5
Rice	3.2	1.5	1.0	0.7	1.5	1.9	2.8	5.6	8.8	9.8	8.1	5.5	50.4	3.4	50.6
Sudan	2.4	1.5	1.0	0.7	2.0	4.3	5.7	4.8	6.9	7.7	4.9	4.7	46.6	2.4	46.6
Misc. Truck	2.4	1.5	1.0	0.7	1.5	1.9	3.2	4.6	6.7	7.4	5.2	3.7	39.8	1.9	39.3
Misc. Field	2.4	1.5	1.0	0.7	1.5	1.9	2.2	2.4	6.1	7.4	5.0	1.9	34.0	1.9	33.5
Double Cropped with Grain															
Sugar Beets	2.4	1.5	1.0	0.7	2.0	4.3	5.7	3.1	1.8	4.2	5.2	5.8	37.7	3.4	38.7
Field Corn	2.4	1.5	1.0	0.7	2.0	4.3	5.7	3.1	1.8	4.3	6.3	6.1	39.2	2.7	39.5
Grain Sorghum (Milo)	2.4	1.5	1.0	0.7	2.0	4.3	5.7	3.1	1.8	2.7	6.1	5.2	36.5	1.9	36.0
Sudan	2.4	1.5	1.0	0.7	2.0	4.3	5.7	3.1	3.6	7.7	4.9	4.7	41.6	1.9	41.1
Dry Beans	2.4	1.5	1.0	0.7	2.0	4.3	5.7	3.1	3.1	7.6	3.5	1.5	36.4	1.9	35.9
Tomatoes	2.4	1.5	1.0	0.7	2.0	4.3	5.7	3.1	2.3	6.6	6.0	5.2	40.8	1.9	40.3
Lettuce	2.4	1.5	1.0	0.7	2.0	4.3	5.7	3.1	4.1	7.4	5.3	4.9	42.4	2.4	42.4
Misc. Truck	2.4	1.5	1.0	0.7	2.0	4.3	5.7	3.1	2.3	6.6	6.0	5.2	40.8	2.4	40.8
Misc. Field	2.4	1.5	1.0	0.7	2.0	4.3	5.7	3.1	4.1	7.4	5.3	4.9	42.4	3.4	43.4
Fallow Lands 1/	2.4	1.5	1.0	0.7	1.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	14.0	1.0	12.6
Native Vegetation 2/	2.4	1.5	1.0	0.7	1.4	3.7	3.8	2.1	2.3	2.6	2.3	2.0	25.8	1.6	25.0
Riparian Veg. & Water Surface	4.6	2.4	1.4	0.8	1.9	4.5	7.4	6.6	9.7	11.8	9.7	7.0	67.8	4.3	67.5
Urban	1.6	0.8	0.6	0.7	1.0	1.0	1.9	2.4	2.4	2.5	2.4	1.9	19.2	1.6	19.2

1/ Applies also to nonirrigated grain.
2/ Applies also to nonirrigated orchards and vineyards

Metric conversion: inches times 25.4 equals millimetres.

Annual Crops
Evapotranspiration (Consumptive Use) Values
(in inches)

Crop and Growing Period	Estimated Monthly Evapotranspiration												
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
Corn													
Normal Crop[1/]													
4/1-8/31						0.9	3.3	7.4	8.7	5.0			25.3
5/1-9/30							1.2	3.7	8.9	7.7	3.6		25.1
7/1-11/15	0.3								2.0	6.7	5.6	3.0	17.6
1976-77[2/]	1.5	1.0	0.7	1.5	1.9	2.2	2.3	5.7	6.9	5.1	2.6	1.9	33.3
Milo													
Normal Crop[1/]													
5/1-9/30							1.0	3.3	8.6	6.8	3.3		23.0
5/15-10/15							0.5	1.9	8.0	7.3	4.2	1.0	22.9
7/1-10/15									2.7	7.6	5.0	1.8	17.1
1976-77[2/]	1.5	1.0	0.7	1.5	1.9	2.2	2.0	5.9	7.3	4.3	2.5	1.9	32.7
Potatoes													
Normal Crop[1/]													
3/1-6/30					1.7	4.3	6.7	4.2					16.9
4/15-8/15						1.2	4.4	7.6	7.5	1.7			22.4
6/1-9/30								3.8	7.9	7.9	4.3		23.9
1976-77[2/]	1.5	1.0	0.7	1.5	1.9	2.2	1.7	4.3	7.4	5.5	2.8	1.9	32.4
Tomatoes													
Normal Crop[1/]													
3/15-8/31					0.4	1.1	2.2	6.0	8.8	6.3			24.8
4/15-9/15						0.6	1.6	4.0	8.6	7.2	2.2		24.2
5/15-9/30							0.8	2.5	7.1	7.8	4.5		22.7
1976-77[2/]	1.5	1.0	0.7	1.5	1.9	2.2	2.6	4.0	8.2	6.0	2.3	1.9	33.8

1/ Evapotranspiration during irrigation period.
2/ Evapotranspiration for the entire season.

Metric conversion: inches times 25.4 equals millimetres.

TABLE A-6
(Continued)

Crop and Growing Period	Estimated Monthly Evapotranspiration												
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Total
Beans (Pinto)[1/]													
Normal Crop													
4/15-7/31						0.3	4.3	7.2	5.7				17.5
5/1-8/15							1.6	7.0	8.0	1.8			18.4
5/15-8/31							0.4	4.8	8.6	5.1			18.9
1976-77[2/]	1.5	1.0	0.7	1.5	1.9	2.2	1.7	5.7	6.2	2.7	2.5	1.9	29.5
Sugar Beets													
Normal Crop[1/]													
1/15-8/31			0.1	0.4	1.1	3.7	6.4	7.4	8.8	7.2			35.1
2/15-9/15				0.2	0.9	2.5	6.1	7.4	8.8	7.6	2.7		36.2
3/15-9/30					0.2	1.2	4.3	7.2	8.8	7.6	5.2		34.5
5/1-1/31	1.6	0.8	0.9				1.3	4.2	8.4	7.7	5.5	3.6	33.1
5/15-2/28	1.6	0.8	0.9	1.7			0.7	2.9	8.0	7.7	5.5	3.6	33.4
6/1-3/15	1.6	0.8	0.9	1.7	1.3			1.7	7.1	7.7	5.5	3.6	31.0
1976-77[2/]	1.5	1.0	0.7	1.5	1.9	2.2	3.7	7.6	8.3	6.4	4.4	1.9	41.1

1/ Ibid
2/ Ibid

The 1976-77 estimated crop ET rates determined as described in the foregoing and the results are shown in Table A-5 provided the basis for determining the total water consumption occurring in the Delta in that same year. Its findings are reported in the main text of this report.

As mentioned earlier, other methods of determining ET rates were investigated. The other methods were not used because either the basic data essential in completing the analysis were incomplete, or the resulting analysis appeared unreasonable. The PET determined as prescribed by Food and Agriculture Organization of the United Nation and used as a basis determining the ET rates of various crops grown in the Delta was found to be the simplest approach which also gave credence to the evaporation pattern.

77739-950 10/78 OSP 1M

CONVERSION FACTORS

English to Metric System of Measurement

Quantity	English unit	Multiply by	To get metric equivalent
Length	inches (in)	25.4	millimetres (mm)
		.0254	metres (m)
	feet (ft)	.3048	metres (m)
	miles (mi)	1.6093	kilometres (km)
Area	square inches (in^2)	6.4516×10^{-4}	square metres (m^2)
	square feet (ft^2)	.092903	square metres (m^2)
	acres	4046.9	square metres (m^2)
		.40469	hectares (ha)
		.40469	square hectometres (hm^2)
		.0040469	square kilometres (km^2)
	square miles (mi^2)	2.590	square kilometres (km^2)
Volume	gallons (gal)	3.7854	litres (l)
		.0037854	cubic metres (m^3)
	million gallons (10^6 gal)	3785.4	cubic metres (m^3)
	cubic feet (ft^3)	.028317	cubic metres (m^3)
	cubic yards (yd^3)	.76455	cubic metres (m^3)
	acre-feet (ac-ft)	1233.5	cubic metres (m^3)
		.0012335	cubic hectometres (hm^3)
		1.233×10^{-6}	cubic kilometres (km^3)
Volume/Time (Flow)	cubic feet per second (ft^3/s)	28.317	litres per second (l/s)
		.028317	cubic metres per second (m^3/s)
	gallons per minute (gal/min)	.06309	litres per second (l/s)
		6.309×10^{-5}	cubic metres per second (m^3/s)
	million gallons per day (mgd)	.043813	cubic metres per second (m^3/s)
Mass	pounds (lb)	.45359	kilograms (kg)
	tons (short, 2,000 lb)	.90718	tonne (t)
		907.18	kilograms (kg)
Power	horsepower (hp)	0.7460	kilowatts (kW)
Pressure	pounds per square inch (psi)	6894.8	pascal (Pa)
Temperature	Degrees Fahrenheit (°F)	$\frac{t F - 32}{1.8} = t C$	Degrees Celsius (°C)

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